

Interconnection agreements in telecommunications networks: from strategic behaviors to property rights.

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Abstract : The competitive provision of network services has led to the modularization of the underlying infrastructures. But for the network operators, interconnection agreements are becoming a strategic stake and a source of tensions and interest conflicts. Moreover, the contractual modalities of interconnection are largely designed by institutions (in particular by the regulatory authorities). We analyze the relationship between the interconnection policy of network operators and institutional actions of public authorities, by using the theoretical frameworks of network economics and new institutional economics. We show that the interconnectable modules in the networks are not only defined by the technology, but also by institutions which can even uphold property rights on these networks. From this point of view, the comparison of Internet and telephony provides some interesting lessons.

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1. Introduction

Interconnection regulation is a major issue for the liberalization of energy and telecommunications networks. Surely, it is a focal point for tensions and interest conflicts among operators. In France for example, the Telecommunication Regulatory Authority (ART) has to settle disputes concerning interconnection. These conflicts, opposing most often the incumbent operator France Telecom to

its new competitors, deal with the unbundling of the local loop or the termination charges of calls from fixed to mobile networks.

Generally, interconnection has a precise objective : the subscribers of the interconnected networks are given the opportunity to have access to more subscribers (telecommunications) or more suppliers (energy or water). Interconnection requires a technical harmonization, as well as a contractual, often bilateral, arrangement among network operators. More precisely, in an interconnection contract operators define the conditions of access to their networks and the corresponding usage rights. In this paper we will consider mainly telecommunications networks (voice and data). But many economic issues raised are equally relevant, *mutatis mutandis*, for other interconnected networks.

In telephone networks, interconnection agreements have been strongly influenced by the institutional framework in which they have emerged. For a long time, the telephone services relied on the principle of “network integrity”. This notion appeared in the US at the beginning of the XXth century, under the influence of T. Vail, the AT & T’s CEO of that time, to justify the monopoly given to his private company. As long as only national monopolies provided voice services, interconnection was merely a problem of international, diplomatic bargaining. For data networks, the relationships concerning the right of usage, have been strongly influenced by the academic origin of Internet. Interconnection took the form of peering agreements, which enabled several hundred networks to exchange traffic without monetary compensation.

With the development of competition in the telephone services and the rise of “business” Internet, one can expect a reassessment of the strategies and governance structures for interconnection. What is the most relevant framework to analyze this evolution ?

Network economics is one of these frameworks. The first theoretical papers on network economics were aroused by the AT & T breakup in 1984. In this literature, interconnection agreements are treated as strategies for compatibility (Economides, 1996). Interconnection or compatibility choices are proved to depend on the initial structure of the market and on competition modalities. In the case of telecommunications networks, interconnection is obviously different in a market with a former monopoly incumbent (fixed telephone) and a market without an historical leader (mobile telephone). Briefly, two interconnection issues are possible. The first one deals with the access to an essential facility ; there is an asymmetric relationship for vertical compatibility. Without interconnection, some operators cannot deliver their services to the final customer, and have to quit the market. In the second case, interconnection leads to horizontal compatibility among competing services. It is a symmetric relationship, since each operator has a direct access to its customers. Without interconnection the operators can provide services but do not fully exploit the network externalities. Papers dealing with those two issues stress the anti-competitive effects of interconnection agreements, when operators freely bargain. Some of

those agreements may deter entry or favor a collusion on prices. A public intervention seems thus necessary to control the operators' behaviors and possibly to establish interconnection and usage rules, particularly in the asymmetric case.

If this first approach highlights the impact of interconnection strategies on the competition game, it says nothing upon the institutional setting in which these agreements are convened. Interconnection is an *meta* game in which intervene not only operators, but also their suppliers, their customers and the public authorities (Government, Parliament, Regulation Agencies). The stake is about the definition of property rights and their assignment to the network operators. To study this issue, the neo-institutional theory is better suited. This approach enables us to better understand the links between technical and institutional changes in the networks. In particular, the possibility provided today by technical progress to split the networks very finely, is accompanied by institutional innovations, with which the interconnection strategies of the operators have to cope.

In section 2, we analyze the interconnection agreements as a strategic dimension of the competition game, by using the network economics. In section 3 we analyze interconnection agreements through the lens of the neo-institutional theory.

2. Interconnection agreements as a strategic game

For an operator, its interconnection choices have an overwhelming influence on the diversity of its services, their quality, their price. They also condition its profitability, hence its survival in the market. Moreover, although operators always have the possibility of revising or renegotiating their agreements, it seems that interconnection decisions are less flexible or are more involving than tariff decisions. For all these reasons, interconnection strategies have to be analyzed in a sequential game in which the operators set their interconnection policy at the first step, then define their provision of service in a second step. This game theoretical framework enables us to deal with two issues : on the one hand the decision to interconnect or not with another operator, on the other hand the contractual conditions of this interconnection. Those questions are raised differently whether operators have an asymmetric relationship (section 2.1) or a symmetric one (section 2.2.).

2.1 Asymmetric interconnection and the essential facility

An asymmetric interconnection agreement reflects a vertical relationship, whereby an operator needs the other for its own service provision. The latter, who owns a facility essential for the former, benefits from a strategic advantage whose he can abuse. If he has the possibility of freely determining the access conditions to his network in conformity with his own interest only, he is in a situation of a

regulator of the competition game. The establishment of a public regulation is deemed necessary to limit this power and to give the control of the competition game back to the public authorities.

The access to an *essential facility*

A carrier owns an *essential facility* if the others cannot duplicate with reasonable costs such an infrastructure. In telecommunications and energy networks, the access to subscribers is such a facility. In particular, the local loop in telecommunications and the distribution network for gas and electricity are bottlenecks through which competitors have to pass. The joint use of an infrastructure by competing operators thus raises the issue of access conditions. A limited access at high prices may curb the development of competition and new services.

However, the problem is different whether or not the owner of the essential facility provides himself competitive services. If he provides interconnection only, his objective will be to extract the profits of the operators using his network. Thus, he will set an access charge to his facility high enough to capture all their profits. Meanwhile it is in the owner's interest to provide end user services himself (Economides and Woroch, 1992). This vertical integration strategy may even be favorable for consumers, since the price of the end user service may decline. This result holds from the elimination of the double margin when the supply of the service is vertically integrated, a classical result shown by Cournot (Economides and Salop, 1992 ; Economides, 1999).

Vertical integration, however, reinforces the risk of monopolization. The integrated operator may well deny the access to his essential facility in order to obtain or maintain a monopoly on the final service. This strategy is called foreclosure. In telecommunications for example, the operator that controls the local loop (the local network), can easily monopolize the market of long distance calls¹). For this, he can use either the access price or access quality to the local loop, in order to raise rivals' costs or to downgrade their quality of service (Economides, 1998 ; Economides and Lehr, 1995 ; Beard, Kaserman and Mayo, 1996).

If competition is about strongly substitutable services, or if operators have no capacity constraints, it is clear that a vertically *integrated operator* has a strong incentive to exclude his competitors, to prevent them from stealing his business. Conversely, if operators have capacity constraints or if they provide differentiated services in quality or in variety, the incumbent can in principle gain by letting them enter : he can account for new revenues from the access to his essential facility, thereby balancing the profit losses on competitive services (Economides and Woroch, 1992 ; Penard, 1999). But these results hold in a static framework. In

¹ This was AT & T's attitude when MCI entered this market in 1963.

the long run, operators can always overcome capacity or variety constraints and foreclosure seems the most robust strategy. Beyond the concern about anti-competitive behaviors, fairness issues are also raised : it seems questionable to leave to an operator who has, for historical reasons, inherited from an essential facility, the right to establish the rules of the competition, namely the right to decide who can use his infrastructure or not. Efficiency and equity arguments thus call for a regulation of access conditions to essential facilities.

Access regulation

The objective of regulation is to open the access to the essential facility and to promote competition on the complementary services. In such a perspective, the regulator must intervene on the rights and obligations of each operator. He can make interconnection compulsory or establish some modalities in the contractual agreements among the operators (point of access, tariffs...). However, the regulator must be conscious of the dilemma faced by the owner of the essential facility. When the latter invests in the capacity or quality of his facility, he can provide better services to the end users, but his competitors that have access to his infrastructure, can also improve their services. In other words, he partially benefits from his investments. This situation may lead the integrated operator to underinvest in his essential facility as shown by Armstrong Cowan and Vickers (1994) in the case of the UK. This trend is even stronger if the incumbent expects an unfavorable evolution of the regulation (increase of the access points to his network or decrease of the access tariffs). Thus the regulator has to make sure that the former monopoly is paid enough for the use of his network and for his investment. Conversely, high access charges may lead the competitors to invest in inefficient by-pass infrastructures (Curien, Jullien and Rey, 1998). What should the appropriate tariff for the access to the essential facility be?

The regulation of access tariffs to an essential facility is complex, when one considers that most of the network costs are fixed and shared with other activities of the incumbent. Several rules of efficient regulation have been proposed, in order to recover the costs of usage of the facility. Baumol and Sidak (1994) recommend to tariff the access at its opportunity cost that corresponds to the marginal cost of giving access to the infrastructure, plus the loss of revenue for the owner, due to the competition on the complementary services. This rule is called ECPR (Efficient Component Pricing Rule). Its advantage is to prevent the entry of less efficient operators than the incumbent. The efficiency of this rule has been theoretically put into doubt (Armstrong, Doyle and Vickers (1994), Economides and White (1995, 1998)). Spulber and Sidak (1994) claim that the regulated access tariffs should comply with at least one condition of voluntary interconnection : that means that the interconnection must be profitable for the owner of the essential facility. Finally Laffont and Tirole (1994) suggest to apply a Ramsey-Boiteux tariff for the access to a local facility. This rule recommends setting access charges inversely proportional to the price elasticity faced by each of the alternative operators. Interconnection charges paid by an operator will thus

be lower whenever the price elasticity of his services is high. Laffont and Tirole generalize these results to the situation where the regulator knows imperfectly the costs and behavior of the incumbent. Therefore an efficient regulation consists in a menu of interconnection contracts proposed to the incumbent, to induce him to reveal his true cost and to provide enough productivity efforts. But these incentive schemes leave an informational rent to the incumbent.

The implementation of these efficient rules, although analytically convincing, is difficult to apply. Most regulatory agencies in telecommunications have chosen a method grounded first on accounting costs (or historical costs) and then, when their knowledge of the costs improves, on the long run incremental costs, to which profit margins on invested capital are added. Only New Zealand has tried to apply the ECPR rule, but abandoned it after several litigations triggered by new operators (Blanchard, 1995). In France, as in most European countries, the public authorities have heralded the principles of transparency, fairness and efficiency in the interconnection regulation. Moreover, they have forced the incumbent to answer positively to interconnection demands and to offer cost oriented prices. The latter is also subject to accounting separation that is a first step towards a better knowledge of the operator's cost, in conformity with the concern of the regulator to fix the interconnection prices as close as possible to the usage costs of essential facilities. Regulation thus reduces the contractual freedom of the incumbent, both for the choice of counterparts and the choice of tariffs. Recently, public authorities wished to go further in this way, by enforcing an interconnection obligation for the incumbent, as close as possible to the subscriber: this is the unbundling of the local loop.

Interconnection to essential facilities is not the only type of agreement examined in network economics. Agreement among symmetric networks are also subject to numerous although more recent papers.

2.2 Symmetric interconnection and compatibility

An interconnection is symmetric when two operators have a direct access to their customer on the one hand and are in competition on the other hand : for example an agreement between a fixed and a mobile network operator, or an agreement between Internet backbones. Symmetric interconnection raises the issue of both quality and prices of services that operators provide to each other.

Competition and compatibility

Symmetric interconnection is first an issue of compatibility. Operators have to know whether they allow their customers to access the networks and services of competing operators, while providing as a counterpart their own services to the latter's customers. This choice will depend on two opposite effects. On the one hand interconnection enables the customer to benefit from network externalities.

Since the network size and the number of services increase, the customers' willingness to pay increases too. Operators can thus raise the price of their services without reducing the customer utility. On the other hand interconnection brings networks closer with regard to the quality of service. By reducing differentiation, it increases substitutability and price competition among operators. The network effect supports interconnection while the substitution effect (or business-stealing effect) restrains it. The net effect will depend on several conditions concerning the size of externalities the characteristics of demand and of operators (Encaoua, Michel and Moreaux, 1992 ; Katz and Shapiro 1985). For example for Automatic Teller Machines, the compatibility decision will depend, among other things, on the initial size of the networks and interbanking fees (Matutes and Padilla, 1994).

This theoretical framework fits well with interconnection among Internet networks. Many Internet Service Providers (ISP) refuse to be interconnected even if they could benefit of network externalities. Thus Baake and Wichmann (1999) show that a large ISP (with a large number of subscribers) may deny interconnection with a small ISP to keep a quality of service advantage. Dang Nguyen and Pénard (1999) show also that ISP have more incentives to interconnect if they have similar qualities. But compatibility in the case of Internet is less a discrete (whether or not to interconnect) than a continuous choice (which interconnection quality to adopt). Each operator chooses the quality of interconnection through the maximum and the guaranteed bandwidth of the connections set up with other operators.

Few theoretical works finally are devoted to interconnection choices among telephone networks. First, compatibility is compelling : in Europe as well as in the US, any open voice network has to accept interconnection demands, in conformity with quality standards imposed by the regulator. Moreover network effects are considered so large that compatibility issues seem irrelevant.

Financial transfers and collusion

Whether voluntary or mandatory, interconnection requires an agreement between operators on tariffs and financial transfers. The financial counterpart to the service may be fixed or usage sensitive charges. Moreover, they can be set either independently or cooperatively. In most cases the operator directly perceives revenues from the subscribers and transfers part of them to operators terminating the service or the communication.

Compared to this principle, Internet exhibits a specificity since most interconnection agreements, called *peering agreements*, contain no financial counterpart to traffic exchanges. Each operator keeps all revenues stemming from its network customers.

When operators agree to set positive access charges, they face the following dilemma : a high access charge augments the revenue on each incoming call, but limits their number. The net effect will depend on price elasticity of the interconnected users. Laffont, Rey and Tirole (1998a) show that when the operators choose interconnection tariffs non cooperatively, the result is non optimal, with too high tariffs, since operators do not internalize the adverse effects upon the utility and the demand of users. The authors then study the case of a collective determination of interconnection charges. The cooperative choice may reduce competition and increase the retail prices of calls, reflecting a possible collusion among operators. These effects are strengthened when the regulator imposes a non discrimination principle between incoming and outgoing calls, as well as a reciprocity of access charge (the same charge for incoming calls of all networks) ⁽²⁾. If these regulatory constraints are upheld, a cooperative determination of access charges leads to less collusion (Laffont, Rey and Tirole (1997, 1998b)).

One of the limits of these papers is to describe competition in a static framework. Only the impact of interconnection on current profits is considered, without taking its consequences on the competition dynamics into account. In particular, the link between access charges and collusion is never analyzed in an intertemporal context. Without going into details, one can say that the transition from a static to a dynamic framework often reverses the results : this is the topsy turvy principle underlined by Shapiro (1989). For example, if operators want to sustain a tacit collusion on prices, they can punish those who cheat or breach the agreement, by reverting to the competitive static equilibrium. As a cooperative determination of access charges increases static profits, it reduces the severity of punishments and makes collusion less likely. Then a practice that increases current profits may appear as collusive in a static framework, while being pro-competitive in a dynamic one. The results of the previous models, most of them static, should thus be accepted with caution to evaluate the efficiency of a regulation which is essentially dynamic.

To sum up, network economics has the virtue of exhibiting the strategic motivations of operators in the interconnection agreements. This approach focuses on the way operators, but also regulators, interact in the competition game. However, it underestimates the coordination problems met by operators, in a context of strong uncertainty and imperfect information. Moreover, it considers the institutional framework as given, whereas it is well known that operators constantly try to influence the rules of the game and to modify the regulation. The competition game is thus embedded in an institutional game on which depends, in the end, the rules and rights for interconnection. In the next section we will complete the strategic approach with an institutional one.

² Economides, Lopomo and Worock (1996) show however that if a network dominates (with a strategic advantage), the reciprocity rule enables to prevent this network to monopolize all the subscribers. But non discrimination rules (access price equals internal price) and an unbundled supply of service are less efficient.

3. Contract theory and interconnection

Through an interconnection agreement each operator gets a usage right upon a network capacity of another operator. This right is normally reciprocal, but each party is not in a symmetric position, as seen above. Contractual difficulties may result from asset specificity and opportunistic behaviors. The usage right defined in an interconnection agreement may conflict with the operator's property right upon its own network. Thus, the parties have to set up "governance structures" which reconcile the right of usage and the property right. But the choice of a governance structure is not independent of the institutional framework designed by public authorities. The latter can limit or transform any property right on the network. We show that this actually happened in telecommunications, thus illustrating a theoretical issue raised by Williamson (1993), in the continuity of Commons (1934) and North (1990) : how institutions affect governance structures.

3.1. Network evolution, property rights and rights of usage

In a transport network, flows are commanded through an overlay network called "command network". For example, in a railway network, the "command network" is the set of signaling and switching devices. Previously, the command network and the infrastructure network were combined into a *system*, intended to globally optimize the performance of the network. In that context, interconnection meant the interoperability of two systems, both for the command and the infrastructure networks. International agreements for telephone networks followed this principle.

In the eighties, it became possible to split the command and the infrastructure networks. This unbundling was established in 1987 in the US by the ONA ("Open Network Infrastructure") doctrine of the Federal Communications Commission (FCC). It gave the new operators the opportunity to freely combine "modules" leased to incumbent operators. Telecommunications, as well as computer networks, were then functionally broken down. This led to redefine usage as well as property rights upon each module. The question is thus raised of the efficiency and fairness of this redefinition: The analysis of interconnection agreements cannot neglect the breaking down of the networks into modules.

Hence transaction cost theory (TCT) analyses the possibility to separate or integrate several modules depending on their asset specificity. These modules can be either assembled or leased. But TCT says nothing upon the initial definition of modules, on the assignment of property and usage rights, which seems to refer to an institutional power. Thus TCT assumes that modules exist before their possible integration and does not explain how they do emerge. One hypothesis is that the definition of these modules is an institutional issue, which evolves and has to be explained theoretically. Some examples show how this process occurs. The

splitting of a system into modules is often *functional*, and may be linked to a *horizontal* (AT&T's geographical break up in 1984) or *vertical* (break up of IBM's complementary activities, such as software and hardware in the sixties) institutional separation. This splitting also occurred in electricity networks (Joskow, 1996). However, modularity appears to be a major feature of information technology goods and services. The question is thus raised of the effectiveness of this institutional intervention.

3.2. Institutions, transaction costs and assignment of property rights

Functional splitting can be explained by technical progress. Splitting should provide the firms with the possibility of creating more efficient modules, later recombined into more complex services or goods. Williamson (1993) claims that technology provides a *semi weak* determination upon organizational choices, in as much as well-known technological options would limit the governance structures. Institutional intervention would thus ratify technological opportunities. Given the state of the art in technology, separable and well identified modules could be individually appropriated and their ownership rights could be transacted. In the network industries, those modules could be interconnected through contractual arrangements, in order to provide a complete service to the customer.

But the module appropriation is not so clear. Technology provides practically no limit in the separability into modules : it is now technologically possible to split elementary particles or genetic codes. The technical frontier is thus beyond what society considers as a property right, economically or socially sustainable. An intuitive answer to this issue is that the principle of the first mover should apply. Those who elaborate or create the module should be the owners. But all that happened recently in the IT (Information Technologies) suggests that a subsequent reconsideration of the initial assignment of property rights is always possible, precisely through a finer definition of modules. Then only *institutions* have the coercitive right to assign and to question those rights. It is thus essential to know the motives and criteria of institutional actions.

Williamson does not explicitly treat this question. He is more interested in the evolution of "governance structures" than in the initial assignment or the subsequent institutional reallocation of property and usage rights (Williamson, 1981). Nonetheless, he puts forward a principle of "remediableness" to guide institutional actions (Williamson, 1996) : one should only implement institutional reforms which, once achieved, would provide a "net gain". Similarly, Commons (1934) suggests that institutions comply to the principle of "artificial selection" : public institutions choose to favor institutional rules which favor more efficient but also "fairer" transactions (Ramstad, 1994). Following the categories of Commons, the "institutional environment" (institutions), should be conceived to facilitate better "institutional arrangements" (governance structures), in terms of equity and efficiency.

Advocates of the property rights school emphasize the role of property rights structures upon economic performance (De Alessi, 1983). For Demsetz (1998), non institutional conditions, such as the initial endowment of factors or the evolution of exogenous parameters like transportation costs, are essential for the definition of the rules and may lead to the revision of the ownership rights structures. Technology and its evolution could be interpreted as a form of non institutional determination.

Far differently, evolutionary theorists suggest that institutional rules rely on a principle of path dependency (Magnusson and Ottoson, 1996). Once established upon an institutional trajectory, public authorities could not put them into question so easily.

This brief discussion of the motives for institutional intervention raises the following question : why do public authorities periodically decide to modify the “institutional rules” that are applied on the markets ? who is at the initiative of these changes ? We will try to answer these questions through the example of the modularization process that has been occurring in telecommunication networks. However it is necessary to distinguish between voice networks and data networks, where “modularization” has taken a different form.

3.3 Modularization and assignment of property rights in the voice networks

The existence of “integrated systems” in telephony is historically explained by interconnection difficulties among early operators (Muller, 1994). Indeed, networks were initially developed by local governments because intercity networks were too expensive. Competition did exist in the US, but also in France, where state intervention is a tradition. But in the US, the dominant network of the Bell System denied interconnection to their competitors ; their argument was that interconnection would undermine the competitive advantage and expropriate the shareholders of the Bell System. T. Vail, the CEO of Bell, pleaded for the uniqueness of the telephone system with the motto : “one policy, one system, one universal service”. Institutionally, this point of view has become dominant and telecommunications developed through a monopolistic organization, theoretically grounded on the “theory of the natural monopoly” (Sharkey, 1982) : Duplication of infrastructures seemed costly and inefficient. Moreover, complementarity between the local and the long distance networks justified integration into one system, to economize transaction costs. In some countries (USA, Canada, Finland, Danemark...) local and long distance networks were run separately, but coordination structures did exist among the local and long distance monopolies.

In the eighties, a liberalization process took place which can be interpreted as the calling into question of monopolies’ property rights on their networks. However, with the noticeable exception of the USA, there has been no vertical or horizontal separation of ownership, namely no breakup, but a *functional separation* which limited the property rights of the operators upon their networks. The unbundling

of the local loop is an example of this process. Modules are defined by regulation and incumbent operators continue to own the modules, but a usage right is recognized to the competitors to lease them. Now the new operators choose between “make” or “buy” (or rather “lease”) not on the basis of “market” versus “integration”, as in the TCT paradigm, but on “institutionally guaranteed lease” against “integration”. The guarantee goes as far as to define prices, technical interfaces, availability conditions, etc... It thus remains to examine why previously an exclusive (and monopolistic) right of ownership was institutionally recognized to the monopolies up the eighties, and why this exclusive right has been called into question since then.

Clearly, technology is part of the explanation, as suggested by Williamson and Demsetz : the decrease of transmission costs has enabled the duplication of long distance capacities. Vertical separation between long distance and local networks was a kind of “institutional remedialness” in accordance with this evolution. But interestingly, this separation occurred in one country only, the USA. In other countries, it was only limited to an accounting separation, without breakup.

On the other hand, unbundling was more the consequence of lobbying than the search of optimal governance structures. Indeed, the separation of the command and the infrastructure network, the definition of Open Network Architectures was set up at the monopolistic operators’ initiative. The latter were eager to buy equipment in separable modules, in order not to be locked in by one equipment manufacturer. Later, when competition was institutionally admitted in the telecommunications services, the competitors of the incumbent operators took advantage of the existence of these modules to get access, and lease only a subset of modules rather than entire systems with the help of regulatory agencies.

The method that regulatory authorities such as FCC in the US, Oftel in the UK or ART en France, have used to modify the institutional rules on telecommunication markets, is rather original. Instead of proceeding bluntly (break up, obligation to sell and thus to abandon property rights on specific activities), they have adopted a more flexible and “fine tuned” approach, based on the property rights and usage rights. They have been searching for a fine balance between property and usage rights. To some extent, regulation has appeared as an *institutional innovation*, which has created the conditions of challenging the property rights of telecommunications operators for the sake of promoting competition. However, from a “governance structure” point of view, the new operators do not take a “make or buy” decision, but a “make or lobby” decision.

We can thus say that former monopolies initiated modularization to improve their governance structures with their equipment suppliers, but this subsequently led to an *institutional innovation*, which is the enforcement and regulation of leasing contracts among competitors and the former monopoly. This had the consequence of limiting the latter’s property rights on its network, and to promote competition. This institutional innovation had several advantages. First, through the guarantee of interconnection, it reconciled the beneficial effects of competition and network

externality : everybody could access anybody whoever his or her telephone supplier was. Second, as the former monopolists avoided the breakup, they accepted more easily the transition to competition.

It is not clear however, whether the governance structure emerging from this decision process, is really optimal. In other words, do the regulatory agencies provide the right signals and incentives to both the incumbent and new entrants, to stimulate innovation, since the benefits of their ownership of some assets may be upheld and shared with their competitors... Also, lobbying is not an efficient business per se, and may lead to opportunistic behavior : it might be cheaper but socially more detrimental to obtain an extended usage right upon somebody else's asset, rather than negotiate directly for a lease contract, or establish one's own asset.

3.4 Ownership rights assignment for data networks

In the data networks, a modularization process has also happened with the emergence of Internet. The TCP/IP (Transmission Control Protocol / Internet Protocol) clearly defines a boundary between what is "below the IP layer", namely the infrastructure of data flows transport, and "above the IP layer", namely the command network and all Internet services and applications. Hence, an Internet service uses at least two components : a "transport module" and a "service module". The latter may itself be cut into smaller modules provided by different suppliers : access, browsers, applets,...

The infrastructure layer consists in thousands of heterogeneous interconnected networks. Most of the time, interconnection among Internet Service Providers is tacitly convened. ISP often agree to cooperate on data flow transports without financial counterparts (*peering agreements*). For applications "above the IP layer", many innovations such as the Web and its tools (html, http), browsers, search engines, operating systems (Apache, Linux), programming languages (Perl) have been the outcome of a collective development by the Internet community, and disseminated freely (Stallman, 1999). Internet has thus provided an original solution to the coordination issue : *users* themselves have set up the "governance structures", thereby reducing opportunism and transaction costs, that may come out from the sharing of tangible or intangible assets. In such conditions, the public institutions have not had to intervene, and modularization has been achieved on a strictly technical basis. The question of assignment of property rights has been avoided. It is clear that the specific origin (military and academic) of the Internet has been of paramount importance to explain such an evolution. There has been a "path dependant" institutional evolution in the development of Internet which explains why so many services are "free" and why it is so difficult to earn money on the Net. But the diffusion of Internet in the market economy may lead to a profound evolution.

For example *peering agreements* are beginning to be replaced by formal interconnection contracts. At the applications layer, companies like Microsoft and to a lesser extent Sun, have attempted to individually appropriate the collective benefit of the Net. This shows that the public good nature of Internet may perhaps disappear in the future. Conflicts between the advocates of individual intellectual property rights and proponents of the collective appropriation (exemplified by the Free Software Foundation) are becoming more and more relevant. From a public policy point of view, it remains to be seen whether the denial to assign individual property rights upon the modules is efficient and fair in the sense of Commons.

The collective organization of the Internet at the applications level may be justified by the following features : first a software is never finished and benefits from the subsequent improvement of users adapting it for their own needs. Second, by abandoning Intellectual Property Rights (IPR) the innovators may trigger more quickly a network effect (Katz & Shapiro, 1986 ; Church & Gandal, 1992). He or she will benefit by increasing his or her reputation and by providing ancillary (and charged) services.

4. Conclusion

The analysis of interconnection contracts in network industries has underlined the strong interdependency between the competition and the institutional games, where the latter permits to define the property rights, as well as the rules of the competition game. It establishes in particular the role and the scope of intervention for the regulatory authority. We have shown in this context that the regulator has to take into account the asymmetries among operators and the dynamics of competition.

In telecommunications networks (voice and data), modularity has been, without a doubt, not only a technological but also an institutional innovation, which has allowed the stimulation of competition. Its implementation has depended on the nature of the network : in voice transport, it has been accompanied by a partial expropriation of the former monopoly, a *sine qua non* condition of the effective functioning of competition. In the case of data network, there has been rather, at least initially, a “collectivization” of some modules. These difference of institutional choices may be explained by a path dependency : because it was born in the academic community Internet has favored and still favors communitarism. Because telephone operators initially held a monopoly upon a full fledged network, institutions have redistributed some property rights.

Convergence between voice and data networks may lead to a partial elimination of these institutional differences. Indeed, some practices of data networks (peering, free software) do not rely on a stable institutional framework. This framework has to be designed and the property rights to be explicitly assigned. A

convergence of the institutional frameworks is likely to occur for Internet and telephone networks.

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