CHANGING ECONOMIC NATURE OF NETWORK RESOURCES DUE TO NETWORK CONVERGENCE

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Abstract

The advanced technologies of the converged network are going to change the economic nature of the telecommunication network, especially the Internet. The Internet of today is an example of common resources and is suffering the tragedy of commons problem, i.e., it is overused. However, as the new network technologies of the converged network progress, the Internet will change from a common resource to a private resource and the tragedy of commons problem is expected to disappear. This paper discusses how network convergence transforms the economic nature of the Internet and raises new economic issues that we are going to face soon in the era of the broadband converged network (BcN).

I. Introduction

Users of the Internet usually have to pay some amount of fixed fees to get access to the network. Therefore, once users get access to the Internet, they can use the network resources limitlessly without additional charge. In economics, the resource that is available free of charge and whose quantity reduces as more people use it is called a common resource. A good example is the bandwidth capacity of the current Internet because the bandwidth is limited but can be used virtually without limit by users. A chronic problem of common resources is that they are overused and users face soon the depletion of resources. This outcome is called the tragedy of commons. The Internet of today is not an exception.

We may now on the verge of realizing the truth of Hardin's saying, "freedom in a commons brings ruin to all."[1] Traffic (network) congestion and spam mails are stark proofs of so called the tragedy of commons. Traffic congestion is to resource depletion what spam mail is to pollution of environment. The problem of traffic congestion is not so severe as the spam mail problem because of fast bandwidth expansion though, most researchers of the field agree that the Internet of today is being used inefficiently. There have been attempts to reduce such negative externality problems of the Internet by utilizing optimal pricing, charging prices varying with congestion level, and by implementing laws penalizing spammers.[2] However, it is well known that such attempts have been futile in alleviating such problems.

As I discuss in detail in next section, the Internet is a common resource. Why is it classified as a common resource? The answer is that the current Internet does not and cannot differentiate users based on their willingness to pay for the service. The network resources of the current Internet are assigned to users based on the first come first served rule. In other words, the Internet of today does not treat users differently depending on their different willingness to pay that varies with the circumstance users are facing, preferences, income, and so on. This means that all traffics are being treated equally over the Internet, even though the economic values of traffics are widely different with one another. For example, traffics generated by spammers are treated equally with those created by financial institutions in the middle of routing process. However, thanks to advanced telecommunication technologies such as MPLS (Multi-Protocol Label Switching) and explicit routing, the future converged network is able to treat traffics

[1] For more details, see Hardin (1968).

[2] For optimal pricing, refer to McKnight and Boroumand (2000) and Gupta et al. (1997). For non-pricing approaches to protect commons, refer to Lukasik (2000). Bernbom (2000) also discusses various measures for solving network congestion problem.

differently depending on the needs of users. In other words, the network resources of the future Internet will be assigned first to the most valuable traffics whose values are determined by users' willingness to pay. The future converged network that treats different traffics differently according to their values will change fundamentally the economic nature of the Internet from a common resource into a private resource.

This paper discusses how network convergence transforms the economic nature of the Internet and raises new economic issues that we are going to face soon in the era of the converged network. Next section shows that the Internet of today is a common resource by comparing it with road network and discusses that the very nature of the Internet results in the inefficient use of the Internet. Section III introduces the concept of a converged network based on MPLS technology and discusses the characteristics of a converged network that change the Internet from a common resource to a private network. The future Internet based on the future converged network can be seen as a private resource not because it is owned by a private entity but because it is used first by the user who pays the highest price. Section IV discusses the economic implications of the converged network and new issues that we are going to face soon in the era of the converged network. Finally, conclusion follows.

II. The Internet of today: Characteristics and inefficiency

1. Characteristics of the current Internet

In economics goods and services are classified into four types based on two criteria: excludability and rivalry. Excludability means that consumers can be excluded from the consumption of a good or a service. Rivalry means that as a customer consumes a good or a service other customers' ability to use a good or a service diminishes. If a good is rival and excludable, it is a private good even though the good is not a private property.

The road for commuting can belong to any of the four types depending on whether the two criteria are satisfied. A congested toll road is a private good, but if a toll road network is uncongested, it is efficient for a monopoly to provide the service. This is because the competition between uncongested road networks simply means wasting valuable scarce resources in terms of society. The congested non-toll road is an example of a common resource; any driver can use the road for free regardless of congestion level. If a driver joins the congested non-toll road with a car, the speed of all cars on the road decreases. In other words, the level of congestion gets worse as more cars join the road. The road service is overused. If a non-toll road is not congested, it is the case of public good; anyone can use the road as he pleases.

Table 1 Classification of goods

		Rival?	
		Yes	No
Excludable?	Yes	< Private Goods > Congested toll roads The future Internet	< Natural Monopolies > Uncongested toll roads Uncongested toll Internet
	No	< Common Resources > Congested nontoll roads Congested nontoll Internet	< Public Goods > Uncongested nontoll roads Uncongested nontoll Internet

Table 1 shows the analogy between the road network and the Internet.[3] The current Internet service is usually provided by the competing internet service providers (ISPs) in most countries that charge a flat rate for the use of the Internet and sometimes we experience delays in communication on the Internet caused by congestion. Therefore, the current Internet looks like an example of private good; it is excludable and rival. However, the current Internet is a resource very close in its property to a common resource.

The fixed access fee to the Internet and the intermittent congestion on the Internet do not

[3] The classification of road network is originally presented by Mankiw (2004). We added the case of Internet.

mean the current Internet is a private good. In order to better understand the property of the today's Internet, it should be assessed whether the current Internet is rival and excludable. Excludability is first discussed, and then rivalry is second. The fixed fee excludes some users from the use of the Internet but does not play a role as an incentive system that induces users to use the Internet efficiently.[4] Once users get access to the Internet after paying a fee, their objective becomes using the Internet as they please because the access fee is just a sunk cost. Getting access to the Internet is analogous to entering an all-you-can-eat buffet. In terms of users after hooked up, the cost of using the Internet is just the opportunity cost of time they spend and the cost of electricity for computer. Considering that those who have low opportunity cost of time, ceteris paribus, occupy network resources longer time, we can make a statement that the Internet resources are being used inefficiently under the current pricing scheme. Excludability based on price in a market is a system that allocates scarce resources to the people who value them most; however, the pricing system of the current Internet does not function as an incentive mechanism that makes people to reveal their level of needs. In conclusion, the excludability of the current Internet is severely incapacitated.

Second, currently congestion on the Internet is not a serious problem due to the fast expansion of bandwidth. However, as McKnight and Boroumand (2000) point out, new bandwidth extensive applications such as video on demand (VOD) and video conferencing will be devouring increasing bandwidth; eventually the bandwidth of the Internet is a rival good. Therefore, it can be said that currently the Internet is a non-excludable and rival resource, being a common resource.

[4] According to McKnight and Boroumand (2000), Hardin argues that flat-rate pricing inevitably results in the tragedy of commons.

2. Sources of the inefficiency

Roughly, there are three ways to use Internet service. In Korea most users have access to the Internet at home as shown in Table 2. At home for Internet access users pay a monthly fixed fee, and at firms and schools access to the Internet is virtually limitless and for free. Internet users pay a metered price only at Internet cafes based on a time-metered pricing scheme. As shown in Table 2, by and large users have access to the Internet at home, schools and work places.

Table 2 Internet Access Places in Korea (2003.6)

Home	Firms/Schools	Internet Cafe	Etc.
91.1%	55.8%	27.4%	21.3%

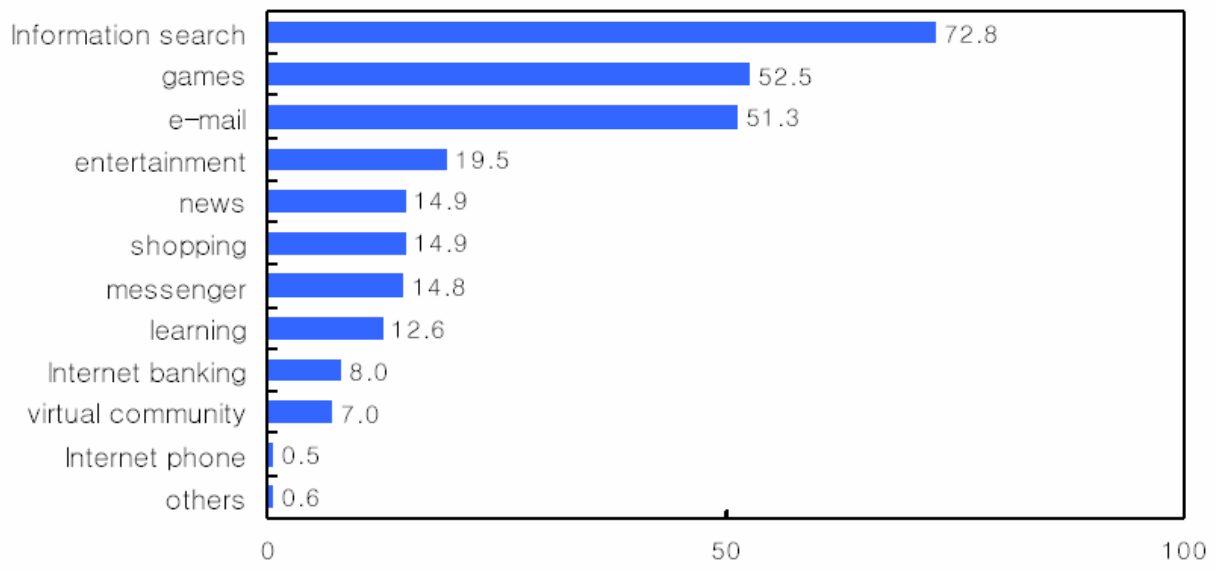
* Multiple responses are allowed.

In terms of economic efficiency there is no difference between the access at home and the access at work places (including the access at schools) because users do not pay any variable fee which is charged by the length of usage time. The ISPs recoup their costs using the fixed rate pricing strategy, but this pricing strategy does not play any role in attaining economically efficient use of the Internet. In other words, current Internet service pricing system is just a tool to recover the cost of providing service; it does not work as an incentive system for efficient resource allocation. This limited role of current Internet pricing scheme is caused by the technical inability of the Internet in providing differentiated services to different users.

The Internet is a common resource as discussed in the previous section, so the resource is allocated on a first-come first-served rule. In order to figure out the usage pattern of the Internet under the resource allocation rule, we need to consider users' cost and benefit from using the Internet. The cost of using the Internet is the time cost of users which varies with the income level of users because once logging into the Internet users spend nothing except their time. Therefore, the cost of using the Internet is increasing with income. The benefit from using the Internet is the personal satisfaction users obtain when they accomplish their objectives. The

objectives can be surfing the Internet, playing a game, finding information, exchanging musics or movies, and so on. Users use the Internet as long as the benefit is greater than the cost. As well known in economics, measuring the benefit and cost is not an easy job. Especially, it is almost impossible to estimate the level of personal satisfaction from using the Internet. However, it is possible to estimate the cost of using the Internet because the time cost of using the Internet is strongly positively correlated with income. Again, income is positively correlated with age. Therefore, other things being equal, young users are likely to use the Internet more than old users simply because young users' cost of using the Internet is low. However, Internet usage pattern by age does not reveal the difference in the time cost of using Internet because the old could have reasons to use the Internet heavily owing to business purposes. Therefore, it is better to check the reasons for using the Internet to figure out who uses the Internet resources. It can be noticed from Figure 1 that a considerable amount of the Internet resources are used for fun rather than productive purposes. The Internet is not being used efficiently in terms of the whole society.

Figure 1 Reasons for Using Internet in Korea (multiple responses, %)



Source: Ministry of Information and Communications. (2004.2) 2003 Survey the Computer and Internet Usage.

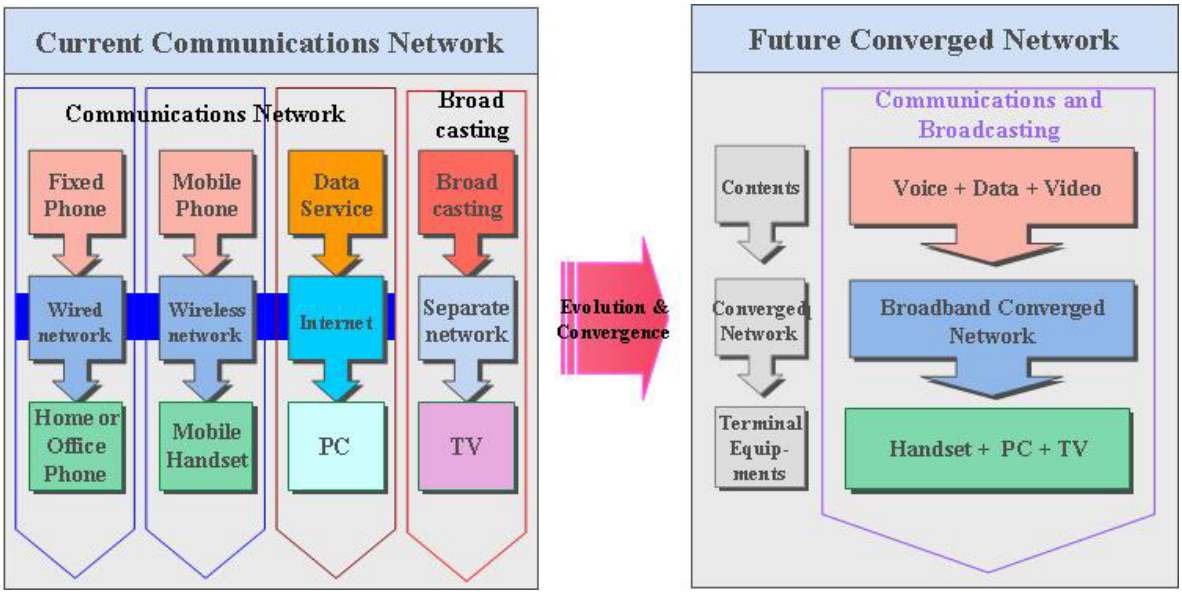
III. Characteristics of the converged network

1. Network convergence: definition

Convergence is a term that has been used widely in telecommunication industry, but up until now there is no consensus on the concept of convergence. The reason of no consensus, we think, is stemming from the word itself. Convergence essentially connotes evolution process to an ultimate state. Therefore, the exact meaning of convergence is likely to be different depending on who uses it under what situation. In the telecommunication industry, convergence has been used with various other words: convergence of services, convergence of terminal equipments, and convergence of networks. This is because, as Blackman (1998) pointed out, convergence had been used to describe several changing trends in telecommunications industry.

In this paper, we focus our concerns on network convergence. Network convergence means the integration of communications networks as shown in Figure 2.

Figure 2 Concept of Network Convergence



Network convergence, we think, is a misnomer because it actually means network integration. Currently four different communications networks are operating for four different services. Traffics of different services flow on different transmission networks and access networks.[5] Two separate telecommunications networks based on circuit switching technology are operating for mobile and fixed telephone services. One data network based on packet switching technology is providing Internet service to users. In addition, broadcasting network which is for one-way communication is offering audio and video programs to users.

As technology develops, all electrical signals can be digitized. Because of digitization of all electrical signals and new compression technology, even voice and video data which requires real-time delivery can be handled by packet switching technology. MPLS is a packet forwarding technology which is gaining attention in network industry as a solution to deliver all types of data on a unified network.[6] As a result, in the near future all types of services shown in Figure 2 will be provided on a broadband two-way communication network. It will become the common communications infrastructure on which all types of services are delivered.

2. Characteristics of the converged network

What makes the converged network unique is not its integrated structure but its characteristics that current Internet does not hold. Palmieri (2004) and NCA (2003) introduce the characteristics of the converged network concisely. First, the converged network is an IP-aware packet switching network. Second, it adopts open interface policy, based on which contents providers can develop various services freely without worrying about hardware dependency.

[5] Surely, some services share the local loop (access network) now, but sharing the access network is not a common phenomena. An example is that the ADSL Internet service and the fixed line voice communication service share the local loop (access network).

[6] For the details of an MPLS, refer to Palmieri (2004).

Therefore, it is also called a multi-service network. Third, the converged network supports various types of terminal equipments through wireless access. In other words, it enables users to enjoy ubiquitous computing. Fourth, the converged network makes use of advanced traffic engineering technologies such as explicit routing, constraint-based routing, and resource (bandwidth) reservation. These advanced traffic engineering technologies become the basis for guaranteeing the quality of service and treating traffics differently according to consumers' willingness to pay.

The fourth characteristic is the key characteristic of the converged network that changes the Internet from the common resource to the private resource. Explicit routing technology enables the Internet service provider to set the path for packet delivery. In addition, if resource reservation is combined with explicit routing, the Internet service provider can guarantee such a high level service as guaranteed on a circuit switching network. In other words, the Internet service provider can allocate some bandwidth exclusively for a specific service. As a result, the Internet service provider can offer differentiated qualities of service (QoS) to different customers depending on the charges they are willing to pay.

As well known, traffics on the current Internet are processed based on the best-effort data delivery. Traffic engineering based on the best effort rule treats all data equally without regard to the values of data. Therefore, it is impossible, under the best-effort service rule, to allocate network resources differently depending on the different needs of users. However, under the new traffic engineering technologies of the converged network enable the Internet service providers create the menu for differentiated QoS. For real-time applications, a high level of service in terms of the priority and reliability of traffic delivery should be guaranteed, and in return for the high level service users have to pay a high price. For non-real time traffics, somewhat lower prices

could be charged depending on the types of services and consumers' willingness to pay.

IV. Economic implications and new issues

1. Economic implications

The converged network can accommodate all types of services and thus it is called a multi-service network. Current networks are mono-functional networks which are dedicated to a specific service. Wire and wireless networks, especially transmission networks, are operating for voice services, and the Internet is operating for data service. In contrast, the converged network is a multi-functional network on which all services are delivered. This feature of the converged network reduces the asset specificity of network resources. Network operators can enjoy the economies of scope by distributing common costs on all types of services. In addition, if there is no strong positive correlation among services in generating traffics, the efficiency in the usage of network resources will be enhanced because sporadic, drastic changes in traffic flow on the network can be mitigated to some degree.

Network operators operating the converged network can develop various differentiated services and different rate structures varying according to the quality level of service.[7] This means that network resources will be allocated first to users who are willing to pay most. The tragedy of commons will be lessened considerably, not completely disappeared though. New services that guarantee a certain level of quality but charge a high price will appear. For example, Internet post office can provide secure, spam-mail free, closed electronic mailing service which is similar Intranet mail system. In addition, VoIP (voice over IP) service can replace traditional wire and wireless phone services when resource reservation and explicit routing are realized on the

[7] NCA (2003) suggests four types of differentiated services based on two criteria: whether bandwidth and quality level are guaranteed.

converged network. This is because the service quality of VoIP will be comparable to that of traditional phone service based on circuit switching. Phone services, which are currently cash cows of network operators, will eventually become just one of many contents (services) provided on a network. The problem of commons will dwindle as the traffics from paid services increase, and eventually the spam-mail problem will subside as well.

2. New issues

The network convergence will give rise to many new issues which the regulation institutions will soon cope with. First, the converged network is a multi-service network, so the costs of installing and maintaining network facilities become common costs that should be shared somehow by contents providers and users.[8] As the share of common costs among total costs increases and the number of services increases, usually the accounting complexity gets more complex. What is worse, the converged network enables network service providers to offer differentiated quality of services for the same service as well as for the different services. Naturally, allocating network costs to services will get so much more complex that we may eventually give up the cost-based pricing. In other words, the complexity of allocating network costs is likely to make regulation authority give up the cost-based pricing rule and adopt a market-based pricing rule. An example pf a market-based approach is allocating bandwidth service by service following the bids made by contents' providers which will in turn recoup their costs from customers.

Second, network convergence is likely to increase the market power of network operators because they enjoy economies of scope on top of traditional economies of scale. Furthermore, as discussed later, network externality that a specific network operator enjoys is likely to be

[8] Here, contents include all types of services such as voice, multimedia, and e-commerce.

intensified because the value of the network depends on the number of contents providers linked to the specific network as well as the number of users (customers). Therefore, the tendency that the bigger gets bigger and the smaller gets smaller will get intensified. This trend will put regulation authority in dilemma because while the monopoly power of network operators rises, the regulation authority may not be able to use traditional price regulation. In addition, because the converged network is a multi-service network, network operators have more room for cross subsidization among services, exacerbating unfair competition concerns between pure contents providers and network operators which are also contents providers. Regulation authority will soon have to devise ways to handle those problems. One approach that regulation authority can use will be prohibiting network operators from entering contents market. This strategy is to admit the fact that network industry is inevitably monopoly or oligopoly in its structure and tries to regulate the price of network service based on the cost principle, while introducing competition policy in contents market. This is the same as separating upstream firms from downstream firms completely in the network industry.

Third, network externality that a specific network enjoys is likely to be intensified because the value of the network depends on the number of contents providers linked to the specific network as well as the number of users. Under traditional mono-functional networks like voice networks, only the number of users has been a key variable in determining the magnitude of network externality because the service provider is itself the network operator. In case of the Internet, only the number of subscribers was also important to the ISPs not because of the network externality in consumption but mainly because of network cost spread over the subscribers. Under the converged network, however, the number of contents providers which are connected to an ISP will determine the number of users who subscribe the Internet service from

the ISP because network operators which have high value added contents providers as members can make greater revenue than other network operators who do not have.

Fourth, when the converged network becomes the basic communication infrastructure in an economy, it would not be easy to find an industry or public utilities which are more valuable than the converged network in terms of both national and international economy. This is because the converged network is a critical infrastructure for daily communication, financial transactions, businesses, education, public services, and everything for living in all countries. The growing economic importance of the converged network will command nations to build organizational and economic systems to handle network security and unexpected, unavoidable risks. It will be necessary for each nation to have a centralized organization which is in charge of network security, monitors network performance, and manages emergencies. Besides, an insurance system of network industry should be developed to cope with unexpected, uncontrollable large risks on the converged network. Studies on the evolution of highway and airline industry would be greatly valuable for the governments that have to develop auxiliary systems for the network industry. In addition, the government should also develop a system to determine who is responsible for the problem. Unlike other industries, it is not easy to determine who is responsible for an economic loss from network problems such as security infringement, forgery, and malfunctioning network because traffics travel many network nodes which are under the surveillance of multiple network operators and contents providers. To attain economic efficiency in the process of assigning the burden of taking preemptive measures to the parties involved, it would be better to focus on who can prevent possible problems at least cost rather than who causes the problem, considering the reciprocal nature of the problems that appear on the network.

Fifth, even in small countries like Korea, multiple network operators will run the

broadband converged network. Naturally, interconnection among the converged networks is inevitable. The problem is that the rules for interconnection charge settlement even under the current Internet are not well developed. Obviously, the variables that the network operators and regulation authority should take into account in calculating interconnection charges are likely to be far more complex under the converged network than under the current Internet. Therefore, developing ways to estimate interconnection charges for data network will be an important issue for both regulation authority and network operators.

V. Conclusion

Recently, Korean government announced that three consortia were selected as the broadband converged network operators that should develop a prototype of the converged network and launch various services through the network within a year. Currently, engineers argue that technically it is possible to implement multimedia services on the converged network. However, they are ignoring that technical feasibility is just one factor that is required to create the full-fledged converged network industry and markets. It is the job of economists to interpret the economic effects and problems caused by new technologies and to suggest and develop policy packages to develop the converged network industry successfully.

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