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Trends in the Commercialization and R&D of New Information Network Infrastructure

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1 Introduction

1-1 The trend toward integration of communications infrastructure into the internet protocol

The telephone was invented in the late 19th century. Telephone networks, created based on a technology called circuit switching, have made the telephone a vital piece of social infrastructure. Meanwhile, television and other broadcast networks arose following the invention of radio communication some 100 years ago. These networks have continued in existence to the present day, forming the core of video-transmission technologies. While telephone networks use circuit switching, a method called packet switching was invented in the early 1960s, and gave birth to the Internet. This technology was originally developed for the transmission of text and other data. Using this method, information is split into small units called "packets," each of which is sent with the destination address. This allows the communication network to be utilized flexibly and efficiently.

Advances in Internet-related technologies have made it possible to offer a wide range of services using packet switching, including voice and high-definition video. Until now, however, different functionality has been provided using completely different infrastructure: voice calls using the telephone network; data communication using the Internet; and video transmission via television broadcasting. Additionally, the telephone network itself includes wired fixed phones and wireless mobile phones. In other words, information networks are part of our social infrastructure, but they are currently not integrated into a single social infrastructure. These services are instead a hotchpotch, each developing according to its own design goals and technology system.

Some argue that we should utilize the packet-switching method used by the Internet to uniformly operate these various communications infrastructures, each with its own history and provenance. The four types of communication above can be summarized as follows.

(1) Data communication, such as email and the transmission of information via the Web (provided via the Internet using packet switching)

(2) Calls using the fixed-phone network (The majority of these communications are currently operated based on circuit-switching technologies. Some are implemented using packet switching, as "Internet phone.")

(3) Distribution of video and audio via broadcast networks (This is generally provided using broadcast-network infrastructure; some new services, such as video distribution, are provided over the Internet.)

(4) Mobile communications using the mobile-phone network (Voice calls use telephone-network technology. Email, Web browsing, and other services use packet-switching technology.)

The Next Generation Network (NGN) is attempting to provide these different types of communications on a uniform communications infrastructure, using packet switching.

The social infrastructure originally built for the telephone is currently undergoing a major transformation. The core of the packet-switching system used on the Internet is a method called the Internet Protocol (IP). IP is one of the fundamental underlying technologies of Internet packet communication. It prescribes things like packet structure and the use of network addresses on the Internet. In other words, IP is at the heart of the NGN's uniform network operation.

Integrating existing communication infrastructure, such as fixed-phone and mobile-communications networks, to use IP (i.e., packet switching) will make it possible to offer a wide range of communications-service functionality, including video distribution, in a uniform way. This will expand the possibilities of creating completely new services. It is also argued that integrating communications networks to IP will reduce the cost of maintaining and managing the equipment used to provide voice-call services.

Telecommunications carriers and telecommunications policymakers in industrialized countries are highly interested in next-generation networks (NGNs) as information and communications infrastructure operated uniformly using IP, in order to replace the declining voice-communication market. Industrialized countries are operating a large number of NGNs on experimental bases. In March 2008, Japan became the first country to begin operating an NGN as a commercial service. Some telecommunications carriers also use the term "NGN" in the marketing materials for their own new services, giving the impression that "NGN" refers to a particular service package. The conversion of communication networks to IP, however, is a trend that no carrier will be able to avoid–even the ones that do not offer physical transmission lines. A wide range of responses to this trend have begun [9,10].

1-2 The start of NGN services

In March 2008, Japan became the first country in the world to begin offering commercial NGN services. The trend leaders in related businesses are large-scale telecom carriers such as Nippon Telegraph and Telephone Corporation (NTT) in Japan and British Telecom (BT) in the United Kingdom.

Table 1 shows some examples of NGN services that NTT has begun. These services all require the company or home to have optical fiber installed. The benefit of these commercial services to the user is that they provide high bandwidth, enabling the transmission of high-definition video data. Quality guarantees are also vital for communication of video data. This depends on whether a function called "bandwidth guarantee"is offered; this function guarantees that a certain volume of packets will be available within a specific period of time.

The fundamental structure of the Internet is designed based what is called a "best effort"network. The Internet has thus traditionally not been very good at guaranteeing communications-bandwidth availability. As an example, when video data like a television broadcast is distributed via the Internet, if the bandwidth of this data is not guaranteed then it may not be possible to transmit a fixed volume of data continuously. If this happens, it causes the quality of the video to degrade, resulting in a jumpy/scrambled picture or dropped frames. This

Table1 : Sample NGN services (NTT)

Service type		Contents of services
	Quality	
Optical broadband service	Bandwidth guarantee and best effort	To detached houses (100 Mbps) To apartments (100 Mbps) To businesses (1 Gbps)
VoIP	Bandwidth guarantee	Hikari (optical-fiber) telephone Videophone
VPN (virtual private networks)	Bandwidth guarantee	(Scheduled to be offered in future)
	Best effort	VPN
Content-distribution services	Bandwidth guarantee	Unicast Multicast
	Best effort	Unicast Multicast
Ethernet service	Best effort	Ethernet

Prepared by the STFC based on reference [9] is what people experience when they access video over a poor-quality Internet connection.

The implementation of bandwidth guarantees is a point requiring attention in relation to Japan's move to digital broadcasts in 2011. Although digital streaming (distribution) of broadcast content has already been achieved, if bandwidth guarantees can be achieved, then it could become possible for the Internet infrastructure to replace the broadcast network. The broadcasters of television programs, however, are cautious about supporting the move to the Internet, because it could cause them to lose their existing rights. In fact, it is possible that for the near future, the social infrastructure of the communication network will continue to develop while serving to supplement the role played by the broadcast network to date. Telecom carriers, broadcasters, and content producers in Japan and other countries are currently competing for business dominance of these emerging application fields.

1-3 Efforts to further develop communication infrastructure

There has recently been a surge in research and development of new networks taking a longer-term perspective. In other words, a debate is beginning over the very core concepts of communication networks as social infrastructure, as we look toward a future beyond the NGNs that are available commercially today. These new networks are called New Generation Networks (NWGN), in order to distinguish them from NGNs. Although the NWGNs being considered essentially have IP at their cores, they are a completely new concept in communication infrastructure that is not necessarily confined by IP.

The study of NWGNs is one of the more important challenges for the research and development of information and communications technologies in each country. The Global Environment for Network Innovations (GENI) in the United States and Euro-NGI in Europe are two examples; these will be described below. An example in Japan is AKARI, a project to design next-generation architecture being implemented by Japan's Ministry of Internal Affairs and Communications (MIC) and National Institute of Information and Communications Technology (NiCT).

As alluded to above, one challenge for the research and development of new information networks like NGNs and NWGNs is building infrastructure that can provide uniform support for a communication networks that have developed along different trajectories, and the wide range of services offered over these networks. Figure 1 provides a conceptual overview of the process of

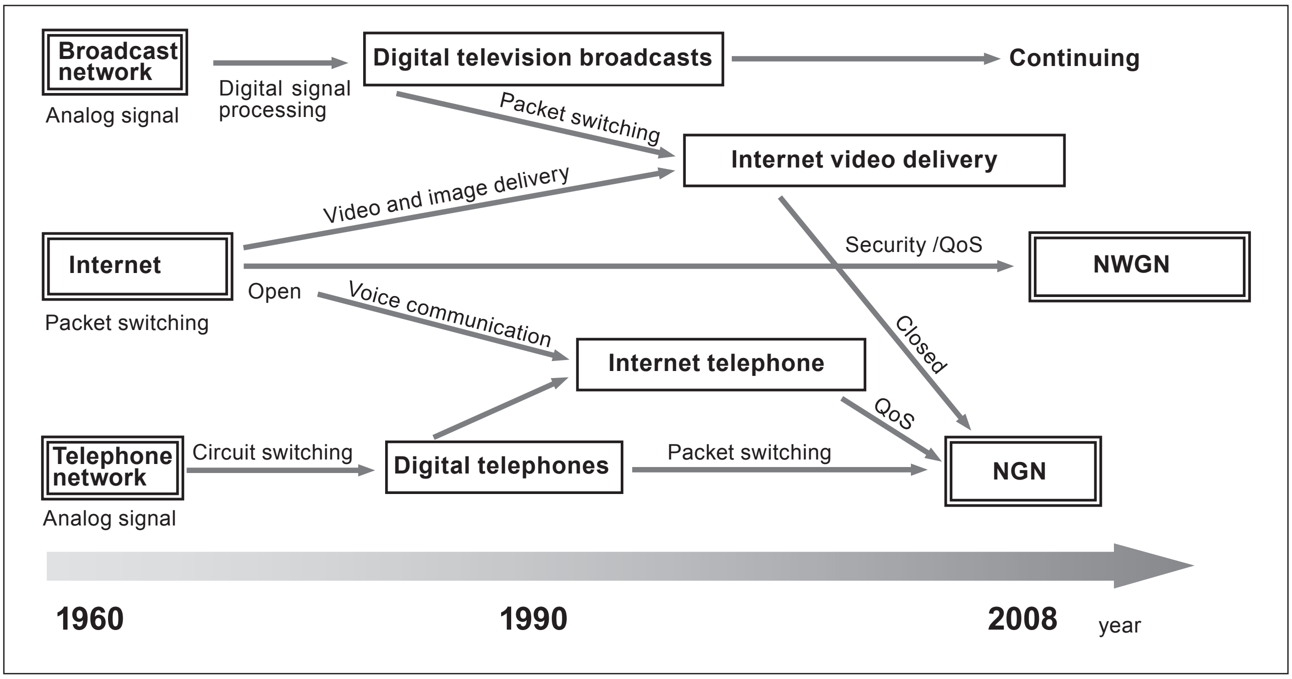


Figure 1 : Technical Advances and the Relationship between NGNs and NWGNs

Prepared by the STFC

merging these services.

Figure 2 provides a conceptual view of the relationship from the broadcast networks, Internet, and telephone networks to NGNs and NWGNs. There are two main elements connecting the broadcast networks, telephone networks, and the Internet: VoIP (voice over IP; also called "Internet telephone") and video distribution over the Internet. These services bring to the Internet functionality conventionally provided by the telephone network and broadcast network, respectively. It is expected that the functionality currently being introduced under the label "NGN services" will be advanced by existing telecommunications carriers. In other words, the trio of telephone, data communication, and broadcasting will progress within the NGN framework through the introduction of quality of service (QoS) guarantees and enhanced security functionality into the IP world.

Research into future NWGNs is likely to progress in parallel to the commercialization of NGNs described above. NWGNs take a longer-term view of network infrastructure. Most research focuses on advances to IP, additionally investigating ways to support low-volume, high-frequency communication on the assumption that ubiquitous networking will have been achieved.

The Internet that uses packet switching has developed as an open network, where anyone can join the communication network. Meanwhile, telephone networks have developed in a closed environment, as strategic national enterprises. NGNs could be called closed services, offered by specific telecommunications carriers. In contrast, NWGNs are attempting to utilize the open environment that the Internet has always had, and which has served as an engine of its growth.

The following and subsequent chapters describe technology trends that are transforming the nature of communication infrastructure, with IP technology at the core. Chapter 2 outlines the commercialization of NGNs being advanced around the world with telecoms-vendor participation (with a focus on ITU-T). Chapter 3 describes research and development of NWGNs, being advanced with a longer-term perspective.

2 Trends in commercial NGNs

2-1 Changing communication needs and the response by telecom carriers

The market needs for communications in industrialized nations began to change greatly in the late 1990s, from voice to data. According to the MIC's Information and Communications Statistics Database, both the number and time of calls are falling significantly for total fixed, mobile, and VoIP telephone calls. In 2000, there were a total of 144.8 billion total calls, with a total calling time of 7.03 billion hours. In 2005, there were 121.1 billion calls, with a total of 4.36 billion hours. These are reductions of 16% and 38%, respectively. As a result, telephone service, once assumed to be a cash cow, is becoming a millstone around the necks of telecom carriers.

According to this database, the total broadband traffic (estimated from the number of subscribers) went from 269 Gigabits/second in September 2004 to 880 Gigabits/second in May 2008-a three-fold increase. Services delivering text, images, music, video, and other content via broadband Internet have also grown at an extremely high pace. A technology called voice over Internet protocol (VoIP) has also emerged. This technology has made it possible to send and receive voice telephone calls over the Internet, sending audio signals using IP. This has made the inevitability of providing telephone and Internet services separately less apparent. Functionality to guarantee bandwidth is being created in the NGN frameworks; if this functionality is added to VoIP, it will become possible to control the audio quality and delays of the conversation according to the call rates.

Telecom carriers in Japan have also started to change their business strategies, in response to new market demands relating to communications. They have reduced spending on networks for telephone services to the bare minimum required for maintenance and management, and are refraining from investing in equipment updates. As a reflection of this, the size of the switch market is shrinking at a tremendous pace. According to a study by the Communications and Information Network Association of Japan (CIAJ), the total value of the Japanese switch market was 142.7 billion yen in 2007, a 29% decrease from the level of 200.9 billion yen two years earlier, in 2005. Despite this decline, however, there is still huge demand for voice telephone calls. This gave rise to the idea that calls should be conducted over the Internet using VoIP, integrating the telephone and Internet networks. The result was the NGN.

2-2 Source of the NGN

In the late 1990s, many telecom carriers in the industrialized world realized the potential of NGNs, and began researching them. The group that advanced the standardization of third-generation mobile phones were the ones that began moving actively to actually utilize NGNs. They first considered the possibility of introducing IP in mobile communications. In particular, they studied such methods as managing addresses according to use movement. These studies came together in a new standard for mobile communications. The international standard for third-generation mobile phones became available right in the very early 2000s. But the worldwide adoption of third-generation technology has been slow, and second-generation mobile phones continue to gain greater penetration worldwide. According to figures in a flash report released by the GSM Association on 22 September 2008, there are 3,804,060,000 mobile-phone users worldwide, of whom 3,059,130,000 – 80% of the total – use the older second-generation GSM (Global System for Mobile). On top of this, the number of these users increased by 800 million over a year and a half.

The numbers of users are growing especially in Asia, South America, Africa, and Eastern Europe. There are few fixed phones in these regions, and when installing means of communication there for the first time, it is cheaper than laying phone lines. This is why GSMs are chosen, and why they are growing so rapidly.

A second-generation phone costs only a third as much as a third-generation phone. This gap will need to be closed in order to for third-generation mobile communication to be popularized. One idea that has been proposed as a trump card for achieving this is saving on costs by building the core network using Internet technology. The idea is to use Internet communication devices for mobile voice communication, because they can be supplied relatively cheaply. This is called an "all-IP network." The international standard IP Multimedia System (IMS) was created from a background of active initiatives of this sort. This could be called the source of the NGN.

IMS adopted the Session Initiation Protocol (SIP), which is a protocol for controlling multimedia sessions, including voice, using IP. When viewing a Website, the user sends a request consisting of a URL (Uniform Resource Locator) that is about 30 characters long, and large amounts of text, images, and other data are sent back in response. In contrast, in a telephone call, the caller and callee are in an equal relation in terms of the amount of data sent. SIP was developed in order to facilitate the sending and receiving of data between two parties in this type of equal relation. This technology is being used to convert the mobile-phone communication network to use IP as well.

2-3 Creation of an international standard for NGNs

The international standardization body ITU-T plays a leading role in communications protocols and other efforts to achieve NGNs. Telecom carriers around the world are members of the ITU-T, and it takes commercial perspectives into account for offering these services. Table 2 shows the most important and distinctive features demanded of standards for NGNs.

The European Telecommunications Standards Institute (ETSI) is one of the leaders in the standardization of third-generation mobile phones. The ETSI has begun working to extend the all-IP network from mobile to fixed communications. It advocates a communication protocol called Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) for achieving this.

The ETSI has started to get results from its standardization efforts relating to TISPAN. It has brought these results to the International Telecommunication Union Telecommunication Standardization Sector (ITU-T), and begun international standardization as an NGN. At the general assembly of the ITU-T held in October 2004, the standardization of NGNs was identified as the number-one challenge, and this has

Table 2 : Main features of NGNs

	Feature
1	All-packet network using IP
2	Support for broadband capabilities and wide range of last-mile technologies
3	Separation of transport (network) and services
4	Full separation of control functionality and services
5	Provides a wide range of multimedia services, including voice as well as video and data, in a modular fashion
6	The framework enables a service to provide the same experience no matter how the user is connected to the network
7	Guarantees end-to-end quality of service (QoS), in accordance with the network quality and the user's device
8	The framework identifies users by assigning them IP addresses and IP-network routing
9	Ensures interoperability with existing networks
10	It is possible to access a wide range of service providers, freely and without restriction
11	Provides a high level of mobility, including ubiquitous access
12	Provides seamless communication over fixed and mobile networks
13	Complies with restrictions, including emergency response, and ensuring privacy and security

Prepared by the STFC based on ITU-T recommendations and other documents

subsequently sparked international discussion.

The first ITU-T recommendation was titled "General Overview of NGN," commonly known as "Y.2001." This recommendation, which was published in December 2004, defines the framework and architecture model for NGNs. The definition in the recommendation is as follows:

"Next Generation Network (NGN): A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies. In this network, service-related functions are not only independent from underlying transport related technologies, but also closely related with each other for supplying services. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users."

This definition is somewhat abstract. Although the integration on IP is still the fundamental nature of NGNs, this definition by the ITU-T may be leaving some room for interpretation, giving consideration to the different situations of telecom carriers in various countries.

2-4 Experiments relating to NGN and current situation

NGNs have been operated on a test basis in many industrialized nations. Although the status of these tests has been reported widely, Table 3 lists data compiled by the Organization for Economic Co-operation and Development (OECD)[1]. NGN experiments have been run in many countries: Austria, Canada, Finland, France, Germany, Italy, Japan, Korea, Poland, the United Kingdom, and the United States. This shows that NGNs are a challenge common to the industrialized world, and that Japan has not particularly taken the lead in this testing. Table 3 also suggests that manufacturers of telecommunications devices are cooperating in this testing as partners.

There are two types of NGN experiment: The first type of experiment is building the communications network itself. Verification of service quality and the like fall into this category. The second type of experiment tests NGN services. Elisa Communications in Finland, KT in Korea, and Qwest in the US are conducting this type of experiment.

2-5 Status of NGN adoption in the West

In 2001, the United Kingdom published "UK Online: the broadband future." This document defines the country's vision for domestic communications infrastructure. In September 2004, then-prime minister Tony Blair declared that they would "bring broadband technology to every home in Britain that wants it by 2008." It would be fair to say that the UK is placing more focus on broadband convergence than other European nations. The telecom carrier BT has announced that it would convert its telephone network completely

Table 3 : Status of NGN Testing in Various Countries

Telecommunication network operators (Country)	Research and test activities	Partners
Telekom Austria (Austria)	Preliminary tests over last 2 years	
Bell Canada (Canada)	Operating 'Innovation Center' and other R&D laboratories	Nortel
TeliaSonera (Finland)	Developed NGN and platforms	Tellabs
Elisa Communications (Finland)	Research on NGN architecture and protocols	
	Launched the 'NGN and new communication service R&D project	
France Telecom (France)	Carried out experiments for NGN	
	Developing 'QoS monitoring systems'	
	Developing NGN architecture for mobile/fixed networks interoperability	Siemens
	Developed network architecture for NGN	Alcatel
Deutsche Telekom (Germany)	Implementing a pilot project	Alcatel, Siemens
Telecom Italia (Italy)	Established 'Telecom Italia Lab'	
NTT (Japan)	Runs a R&D program focused on RENA	
KT (Korea)	Establising test-bed for NGN	Lucent
	Launched a softswitch development project	LG
	Started to develop an application service test platform	Intel Korea
TP (Telekomunikacia Polska) (Poland)	Started NGN R&D project	France Telecom
BT (UK)	Align technology and sales	Cisco
Qwest (US)	Developing broadband business multimedia services	Cisco

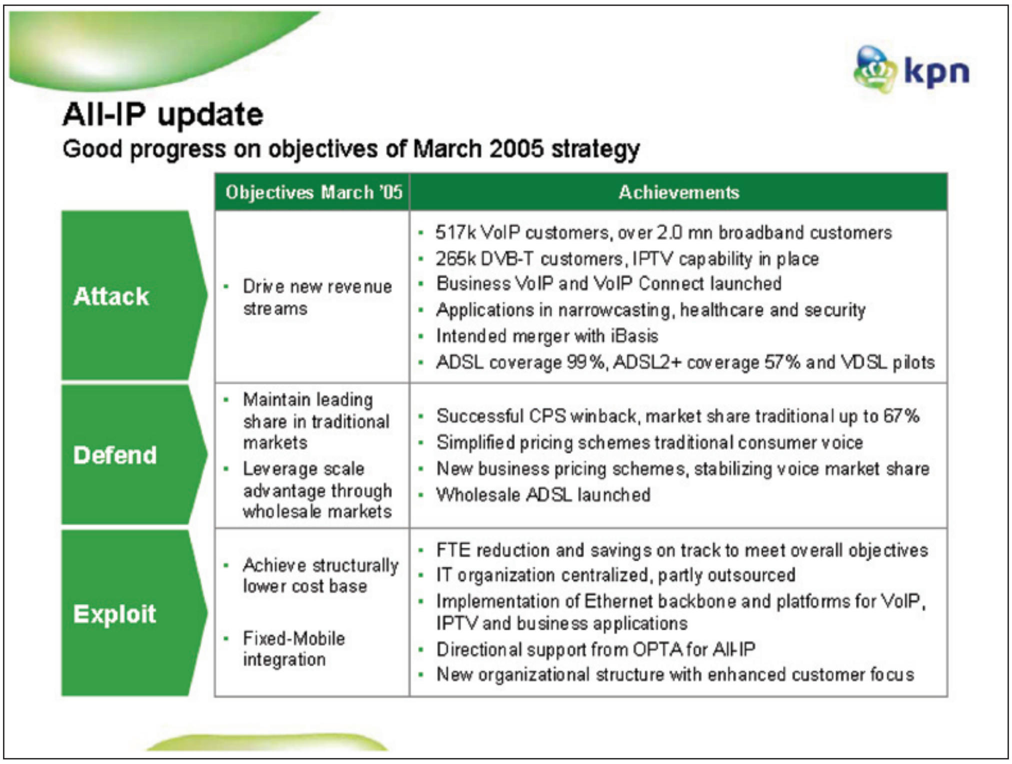
Prepared by the STFC based on reference [1].

to IP, and it is also focused on converting to broadband. Until now, BT has built separate networks for each service. As a result, it now has 16 of them. In the future, the company plans to merge all of these into a broadband IP network. The next-generation network that BT is building is called "21CN" [3]. The company is investing £10 billion (about ¥2.5 trillion) on this project. BT has begun converting to an IP network starting in southern Wales, based on the 21CN plan. BT plans to switch over 115,000 users per week over the four-year period from 2007 to 2011. A total of 5,500 subscriber switches will be connected to 100 metro nodes, which will in turn be connected to the core network in 14 locations.

Although the same move is underway in Finland, Germany, and Italy as well, what is going on in the Netherlands in particular is symbolic insofar as considering what the NGN should be like. Figure 2 describes the situation in the Netherlands, which is relatively advanced. The Dutch telecom carrier KPN has already started to convert its network to all IP. This strategy includes connecting connection points called cabinets installed along roadsides using optical fiber. There are a total of 28,000 cabinets, and the total investment will be €900 million. The company calculates that it can save a total of €850 million in operating costs by switching to an NGN, so in terms of investment it makes economic sense. KPN also plans to offer optical fiber as much as possible to new customers starting in fiscal 2007 [2]. Creating an NGN requires new capital investment. This increased cost can be recovered over the long term through reduced operating expenses. KPN is advancing its plan to create an NGN under this logic.

The United States has been slower than Europe overall. Some telecom carriers, however, have launched IPTV service, which offers television broadcasts via broadband. The selling points of IPTV include more channels than cable television; digital recording features; and the ability to control digital recording via the Web.

The various countries' telecom carriers are split over whether to offer services like video distribution, or to just offer an NGN as a



	Objectives March '05	Achievements
Attack	• Drive new revenue streams	• 517k VoIP customers, over 2.0 mn broadband customers • 265k DVB-T customers, IPTV capability in place • Business VoIP and VoIP Connect launched • Applications in narrowcasting, healthcare and security • Intended merger with iBasis • ADSL coverage 99%, ADSL2+ coverage 57% and VDSL pilots
Defend	• Maintain leading share in traditional markets • Leverage scale advantage through wholesale markets	• Successful CPS winback, market share traditional up to 67% • Simplified pricing schemes traditional consumer voice • New business pricing schemes, stabilizing voice market share • Wholesale ADSL launched
Exploit	• Achieve structurally lower cost base • Fixed-Mobile integration	• FTE reduction and savings on track to meet overall objectives • IT organization centralized, partly outsourced • Implementation of Ethernet backbone and platforms for VoIP, IPTV and business applications • Directional support from OPTA for All-IP • New organizational structure with enhanced customer focus

Figure 2 : KPN's All-IP target and progress

Source: References [4,5] (according to performance announcement at end-2006)

communication environment. Companies are currently monitoring the reactions of users, while searching for the optimum business model.

2-6 Status of NGN adoption in asia

The Asian country with the most impassioned commitment to NGNs is Korea. In Korea, NGNs are called "Broadband convergence Networks"(BcN). In 2004, the Korean government announced the u-Korea Promotion Strategy as its strategy for creating broadband infrastructure. It will build a wide-area integrated BcN as a seamless infrastructure merging communications, broadcasting, and the Internet. The target of the strategy is to enable connection by 20 million subscribers by 2010.

The targets set out in the u-Korea Promotion Strategy are highly ambitious. The target speed is 1,000 times the speed of ADSL (10 megabits/second to 10 gigabits/second), and they are attempting to accomplish this using optical fiber. Korea's commitment to NGNs is part of its strategy to achieve dominance in the information and telecommunications markets by being the first to attain leading-edge Internet technologies. Korea estimates that the total size of the worldwide market for NGN-related technologies is $180 billion/year. In other words, it expects the NGN market to grow to over half the size of the total network market.

Korea has also contributed many documents for the standardization of NGNs to the ITU-T. When one of the authors was visiting the Telecommunications Technology Association in the fall of 2007, he met with one of the people involved with this effort, and was told the following.

"The Korean government funds many projects, and one of the indicators for evaluating the performance of these projects is the degree to which it contributes to international standardization. Because of this evaluation indicator, Korean companies contribute many documents to the ITU-T. They sent 114 documents in 2005, 102 of which were accepted. In 2006, they sent 150 documents, 146 of which were accepted. This number is sure to increase in 2007."

In other words, the government actively uses the level of contribution to international standards as a measure of the success of the projects it funds. Europe is playing a leading role in the creation of international standards for NGNs. Given this background, the comments above by a person involved with the Korean efforts are extremely interesting.

Next, Chinese fixed-phone carriers invested $25.4 billion in 2005. This investment is being used to build NGNs. In parallel, carriers are converting their mobile-communications networks to use IP. Foreign-owned communications-device manufacturers and others are actively starting up businesses in China. China is also laying international undersea cable in partnership with foreign-owned firms.

The comments of Hong Kong's Telecommunications Standards Advisory Committee also actively promote NGNs: A report published by the committee states that NGNs will connect to the conventional public phone network, and gradually replace its functionality, and that over the long term, conventional public-phone networks will be phased out completely[6].

Singapore calls its next-generation network for mobile communications the Next Generation National Infocomm Infrastructure (Next Gen NII). In 2006, Singaporean government began a call for proposals of a conceptual design [7]. Next Gen NII has ambitious targets, aiming for use connections of 100 megabits/second initially, and 100 gigabits/second in the future. These high-speed connections are naturally expected to support such video communications as high-definition television broadcasts. The total investment is calculated at US $1.2 billion.

The Indian government realized the need for NGNs in 2005, and began policy initiatives to encourage them. The government predicts that NGNs will have a major impact on telecom carriers as well as on consumers, especially in sparsely populated areas. In 2006, the Telecom Regulatory Authority of India (TRAI) published a report emphasizing the following points (paraphrased)[8]:

The government wishes to create a single nationwide license for NGN services (voice, data, and video). It will also make it possible for smaller telecom carriers in sparsely populated regions to obtain licenses for NGN services in those regions. The TRAI believes that both national-scale service and service in sparsely populated regions should be achieved by promoting interconnectivity and unbundling. It also recommends a policy of easing the conditions for obtaining radio licenses in order to promote the dissemination of NGNs in sparsely populated regions.

3 Trends in NWGN research

3-1 Basic concept of NWGNs

While the concept of NGNs described above has been depicted as an extension of existing telecommunications, the research into NWGNs going on around the world deals with completely new network architectures. Researchers are creating a new networking concept, breaking away from the development path that broadcast and communication networks have followed to date, and starting from a blank slate. Their position is that after we have created such networks, we will think about how to migrate to them from our current networks.

The greatest challenge for researching new network architectures is network security. The fundamental design concept of the current Internet contains security vulnerabilities. This is due to the fact that the networks developed in an open state. NWGNs will create safe and secure social infrastructure by minimizing these vulnerabilities to the greatest extent possible. Doing this will require such actions as a revision of the technical system relating to network addresses, and more advanced support for movement by communicators. The management of these networks must thus include closed elements that have been absent from the Internet to date. The Internet has developed in many directions in the current open environment. NWGNs must be flexible enough to encompass the diverse applications that have grown up to date, and support further progress as well. In order to support these demands, which at first glance appear to be at odds, the NWGNs must make it possible to flexibly select the technical infrastructure components, and integrate them within a simple architecture. Below, the authors describe trends in the efforts to research and develop NWGNs.

3-2 Japan's AKARI project

The Architecture Design Project that Illuminates the Path to the New Generation Network (AKARI) is a project that the NiCT has been implementing since 2007[16]. The AKARI project "aims to build technologies for new generation networks by 2015, developing a network architecture and creating a network design based on that architecture." Below is an overview of the design concept, referring to the AKARI project documentation.

The AKARI project first sets out to “pursue an ideal solution for network design from a clean slate without being impeded by existing constraints.” The project is thus studying a grand design for a network to serve as social infrastructure, without being shackled by the historical developments of telephone, data communications, and broadcast technologies described at the beginning of this document. Table 4 lists the research targets of the AKARI project.

These research goals all come back to the design of network architecture. The term “architecture”of course comes originally from the world of construction, and is used to indicate the fundamental structure of the network. The AKARI project is building the ideal architecture based on the following three principles:

(1) KISS (Keep It Simple, Stupid)
(2) Sustainable and Evolutionary
(3) Reality Connection

NWGN research projects outside Japan (described below) also emphasize these concepts, and are taking similar directions in their research. Taking the existing state of information networks as a given, and extending to future development, these are probably essential factors. Below, each of these is described in more detail.

(1) The KISS principle (Keep It Simple, Stupid)

It is said that in the infancy of the development of the Internet, the leader of a development project told his subordinates to “Keep It Simple, Stupid.” If the specifications for the routers and other devices making up the network become too complex, then vendors may capture the market based on specific technologies. The idea behind KISS is to make the technical specifications as simple as possible, in order to guarantee that it is possible to build a network environment through open participation.

KISS must be the underlying principle of the entire network, in order to increase diversity, extensibility, and reliability. If one’s aim is to offer more advanced network functionality, this could make the architecture more complex. This principle is an admonition about making things complicated without due consideration. In order to adhere to this principle, the AKARI project has introduced principled approaches to research and development: “end-to-end,” “crystal synthesis,” and “common layer.”

(2) Sustainable and evolutionary

The diversity and richness of applications that have appeared since the Internet came to be used commercially in the early 1990s gives us an indication of the importance of this principle. Taking mobile phones as an example, applications like browsing Web pages were not envisioned when mobile phones first appeared.

According to the AKARI project documentation, “The new generation network architecture must be designed as a sustainable network that can evolve and develop in response to changing requirements. It is important for the network to have a simple structure and for service diversity to be ensured in end or edge nodes.” It further states, “The Internet to date has also maintained this principle. Having a shared addressing system, while enabling the networks forming subparts of the Internet to manage themselves, has helped make it possible to provide a flexible environment that has engendered diverse growth and development. The new network environment should also have an extensible architecture that encourages the development of innovative new applications.”

The AKARI project is advancing development based on this principle, aiming to achieve self-organizing network design; robust, large-scale networks; controls for a topologically fluctuating network; scalable, distributed controls; and openness.

(3) Reality connection

Many of the technical issues occurring on the Internet today are due to the fact that entities (communicators) in the address space of the network are disassociated from the space of real-world society. To give an extreme example, it is possible to fake the sender of email spam, thus making it difficult to identify the perpetrator. Moreover, sensor networks are being built, and in the near future their use is expected to increase. From an operational and management perspective, there is a need to separate physical and logical

Table 4 : Research targets of the AKARI project

(1) Peta-bps class backbone network, 10Gbps FTTH, e-Science
(2) 100 billion devices, machine to machine (M2M), 1 million broadcasting stations
(3) Principles of competition and user-orientation
(4) Essential services (medical care, transportation, emergency services), 99.99% reliability
(5) Safety, peace of mind (privacy, monetary and credit services, food supply traceability, disaster services)
(6) Affluent society, disabled persons, aged society, long-tail applications
(7) Monitoring of global environment and human society
(8) Integration of communication and broadcasting, Web 2.0
(9) Economic incentives (business-cost models)
(10) Ecology and sustainable society
(11) Human potential, universal communication

Source : Reference [16]

addressing in these networks. There are expected to be scenarios in which a specific location could use a huge number of addresses during a short period of time. At this time, it will be necessary to meet the demands for authentication and traceability for a large number of communication devices. The separation of physical and logical addressing, bi-directional authentication, and traceability have thus been identified as critical research topics.

3-3 America's GENI project

The Global Environment for Network Innovations (GENI) project conducts large-scale research into next-generation networks and their applications, funded by a research grant from the US National Science Foundation (NSF) [14]. A huge research grant of $400 million will be invested into research on next-generation information networks, over a five-year period starting in the fall of 2007.

On 25 April 2007, the project concentrated a year and a half of discussion over the implementation plan, and published a Project Execution Plan, comprising a Research Plan, System Requirements Document, Functional Design, and Construction Plan. In September 2007, the five-year research project began. The GENI project is researching the future of information networks through research and development in such fields as sensors, opto-electronics, systems on a chip, fast, large-scale computation, large-scale databases, and new algorithms, unfettered by the existing Internet framework. GENI's physical layer also consists of a diverse range of network devices, including wireless networks. Meanwhile, on the applications front, experiments using the network are interoperable by means of a software management facility. In order to make this possible, the following four key ideas are critical for the subprojects conducting experiments and R&D.

(1) Sub-project components must be programmable, to support any network environment. (2) It must be possible to virtualize the implementation of multiple components. This permits the operation of experiments designed for continuity over a broad scope. (3) It must be possible for terminal devices and users to seamlessly participate in experiments. Creating implementations at the stage of actual operation enables evolutionary improvement. (4) Components must have modular structures, enabling new technologies to be flexibly added and removed. This is to hold up to dynamic operation.

The NSF's Computer & Information Science and Engineering Directorate (CISE) had a central role in the proposal of the GENI project. It aims to promote computer science, telecommunication technology, information science and technology. Through the CISE, information-network and distribute-systems researchers and academics have discussed this project through several workshops.

3-4 Europe's Euro-NGI project

In Europe, a project called Euro-NGI (Next Generation Internet) is one of the main projects of a basic science and technology program called the 6th Framework Program (FP6). Euro-NGI has been implemented since 2003, and in the subsequent FP7 framework, it was continued under the name

Table 5 : Objectives set out in Euro-NGI plan

1) Integrating and rationalizing the European research efforts - Establishing and Updating a Knowledge Roadmap.
2) Implementing a Strong Program of Jointly Executed Research Activities.
3) Sharing Methods, Tools and Platform Developments.
4) Organization of internal Workshops for a thorough exchange of ideas and knowledge.
5) Facilitating the Information Exchange and the usage of Advanced Communication Tools.
6) Facilitating the Mobility of Researchers and PhD Students.
7) Creation of a European graduate courses program for PhD students to maintain and the high expertise level.
8) Creation of a Summer School as a tool for communication and for training of young researchers.
9) Spreading Excellence.
10) Consolidate collaboration with industry.

Source : Reference [15]

Euro-FGI (Future Generation Internet)[15].

Major research institutes in Europe participate in this project, across national boundaries. The Euro-NGI project is being implemented in accordance with the ten objectives in the Euro-NGI Plan, which are listed in Table 5.

From the standpoint of managing a research project, the greatest challenge for Europe is to holistically expand the research activities within its domain without waste, and integrate the results of this research. The Virtual Center of Excellence was built for this purpose: to integrate the knowledge gained from research throughout Europe. The center uses such means as remote interregional videoconferencing systems and Web-mediated chat rooms for experts, in order to create networks for researchers and share knowledge effectively. Of course, the need for actual meeting and exchange is not forgotten either; there is also mutual exchange of research at the graduate-school level, including by having PhD students advised by professors in different institutions.

4 Conclusions

In order to consider the challenges for research and development of next-generation networks, let us have another look at the research objectives for Japan's AKARI project, listed in Table 4. At most, the only research objectives that are purely technological are (1) and (2); most of them assume regulatory or systemic reforms, or refinement via market competition.

In this document, the authors have argued that from a technological perspective, IP convergence of the networks will drive the next technological evolution in the communications field. The ones with the strongest need for IP convergence, however, are the telecom carriers that want to optimize investment in infrastructure. Although users have heard promises about increased bandwidth, bandwidth guarantees, and the like, the benefits of IP convergence are actually hard for ordinary users to understand.

The objectives in Table 4 that are influenced by non-technical factors (3 to 11) have strong relationships with applications in modern society. Approaches to such matters as policy decision-making and considerations of business marketability will likely prove essential to achieving these research objectives.

Take for example "integration of broadcasting & communication" in item 8. If communication services with guaranteed bandwidth are offered at appropriate prices, then it will be possible for the Internet to take the place of current television functionality, as well as to create new services and businesses. The integration of broadcasting and communication is more a policy issue than a technology issue.

As social infrastructure, the Internet has already given birth to many global enterprises. Moving forward, adding the perspectives of bandwidth guarantees and ubiquitous networking will increase the convenience to users, as well as make possible the creation of new industries that we cannot even imagine today.

Rather than relying exclusively on the views of engineering experts, discussion of the future of information networks will require the knowledge and views of experts in a wide range of fields. Innovation in many fields would be impossible to imagine without the social infrastructure of the network. It is thus necessary to study the impact of NWGNs on research and development in other fields, and discuss measures for them to serve as a foundation for creating innovation in a wide range of fields.

Acknowledgements

The authors gratefully acknowledge the valuable discussion and relevant materials provided by Dr. Masato Shinagawa, affiliated fellow at the Science and Technology Foresight Center of the National Institute of Science and Technology Policy.

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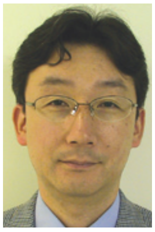
Profile



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(Original Japanese version: published in November 2008)