

A HISTORY OF COMPUTER NETWORKING AND THE INTERNET IN KOREA

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Editor's Introduction: The experience of Korea in developing computer networking and Internet services is interesting and relevant to a worldwide audience for several reasons. One is that it illustrates how a developing nation had the foresight to recognize and join the computer communications and Internet services revolutions in a big way, realizing advanced broadband data access for almost all of its citizens. Are there other innovations today that farsighted people in other up and coming countries might recognize as opportunities for realizing leading roles? A second

reason for attention to Korea's experience, and this article in particular, is its example of how national, regional and global networks develop together, often through key technical meetings and projects. Finally, this article provides, for today's engineers and computer scientists, a fascinating perspective on the different technologies and economic forces involved in an evolution whose outcome was not obvious from the start.

Steve Weinstein, Editor, History of Communications

INTRODUCTION

This paper briefly describes Internet development in the Republic of Korea (South Korea), which started research and development on computer networking in the late 1970s. Korea became one of the first countries to deploy the Internet in 1982 [1], and organized one of the first global Internet conferences in 1985 [2].

In the late 1990s, Korea put much effort into development of broadband networks, starting from a master plan in 1995. Korea became a world leader with widely available wired and wireless broadband networks. Korea also led in Internet applications including online games, search engines and social networking services.

As one of the earlier Internet countries, Korea has been vulnerable to newly arising problems on the Internet such as cybersecurity, net abuse and game addiction. Korea has been trying to solve these problems in collaboration with other leading countries. Korea has also shared its Internet experience with other countries, in particular with developing countries.

A book is in preparation on the early history of the Internet in Korea [3] together with another, co-authored with Internet pioneers in other countries, on the early history of the Internet in Asia.

ORIGINS OF TCP/IP NETWORKING IN KOREA

NETWORK RESEARCH GROUP

Korea's TCP/IP network began with a small computer network research group headed by Kilnam Chon in 1979. The group was formed at Korea Institute of Electronics Technology (KIET), the national laboratory for research and development on computer and semiconductor founded in the late 1970s, which is now a part of the Electronics and Telecommunications Research Institute (ETRI). The group initiated Korean research and development on computer networks. Concurrently, a graduate course on computer networking was created at Seoul National University (SNU).

In 1980, a research proposal to develop the first computer network in Korea was made to the Ministry of Science and Technology of the Korean Government, but it was rejected. A revised proposal was made in 1981 to the same ministry as part of a National Project on Computer Research and Development and was approved. An implementation plan was developed for this project. Initially named Software Development Network (SDN), it was later renamed System Development Network.

The National Project on Computer Research and Development was based on open systems and source software includ-

ing the UNIX operating system. The computer network research group at KIET selected TCP/IP protocols as the base computer network protocols since they harmonized with the UNIX operating systems and the concepts of open systems and source. Other network protocols including UUCP and OSI were also supported [4].

The largest undertaking was development of the TCP/IP router. The ARPANET Interface Message Processor (IMP) from BBN was not available outside USA and NATO countries such as Norway and the UK. TCP/IP protocol development from scratch was rejected since it would take too much time and we were short of competent human resource.

TCP/IP NETWORK

We chose UNET from 3Com, the TCP/IP protocol implementation for Ethernet, rather than the TCP/IP implementation under BSD (Berkeley Software Development). UNET TCP/IP could be ported to any UNIX operating system including System V and BSD without much effort. On the other hand, BSD TCP/IP protocols were machine dependent on DEC computers including VAX and PDP-11. In 1982, with a substantial effort on the router development based on the UNET TCP/IP software, we managed to develop routers based on the PDP-11. A TCP/IP link between the PDP-11 computers of KIET and SNU with distance of 300 km was successfully launched in May 1982 with an initial data rate of 1.2 Kbps. This marked the birth of the TCP/IP network in Korea. Later in 1982, the UNET TCP/IP protocols were implemented on VAX superminicomputers at Korea Advanced Institute of Science and Technology (KAIST). They were further implemented on the SSM-16 UNIX computer from Samsung, a commercial product emerging from the National Project on Computer Research and Development (Fig.1).

The UUCP protocol was also implemented as a complementary network protocol to TCP/IP since TCP/IP implementation required much more computer and network resources. Moreover,



Figure 1. IP router based on SSM-16.

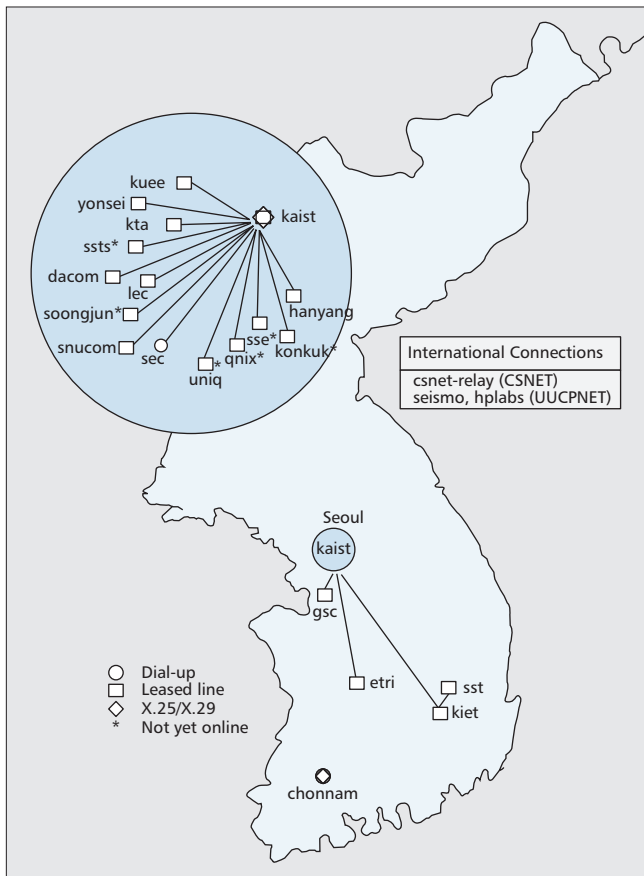


Figure 2. SDN network configuration as of May 1985 [5].

international TCP/IP links such as one with ARPANET in USA were not available then. Thus, UUCP links were extensively used for almost all international networking as well as for many domestic links [5].

Other network protocols such as the OSI protocols and PC communications were also considered for development and deployment. Notable examples included EAN [6], an X.400 message system from University of British Columbia, and the IP-to-X.25 of CSNET [7].

RESEARCH NETWORKS

Korean Research Network

With the successful development of the TCP/IP networks with two nodes in 1982, we were ready to extend SDN to be the backbone of a nationwide research network based on TCP/IP. In 1983, we added KAIST to SDN, and moved the network operation and management center to KAIST where we had a dedicated VAX as the SDN hub. In 1985, we had around twenty universities, national laboratories, and company research laboratories as the members of SDN [5] (Fig. 2).

SDN consisted of the following networks;

- International dialup network with UUCP
- X.25 networks with IP-to-X.25 of CSNET
- OSI network with X.400 and other protocols
- Domestic backbone network with TCP/IP
- * Domestic dialup network with UUCP
- Campus network with TCP/IP

The domestic backbone network of SDN consisted in 1982 of 1200 bps serial line interfaces. Later in the 1980s, the data

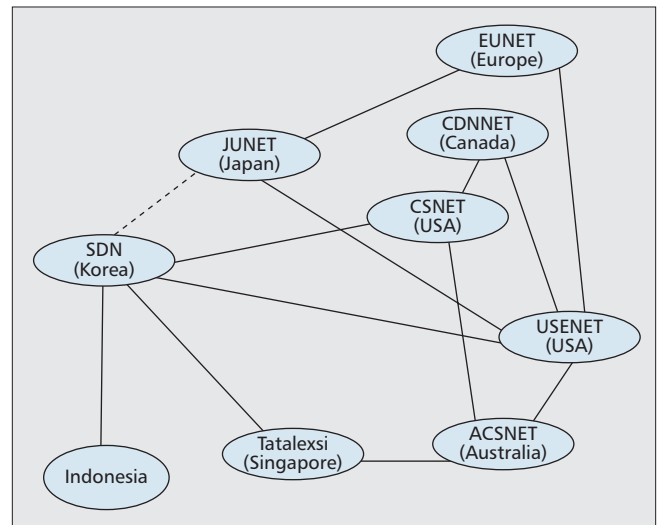


Figure 3. AsiaNet with intercontinental connections as of 1985 [4].

rate was increased to 9600 bps or more. The international networks were either dialup using UUCP [4], or an X.25 network using IP-to-X.25 [8]. A leased line connection to the United States was not realized until 1990 due to the U.S. policy restricting IP connections to foreign countries as well as the high cost of international leased lines.

International connections for SDN had been emphasized since its inception. Dialup links to UUCPNET and EUNET were made in 1983, but bulk data were sent by postal mail on magnetic tape in order to save international telephone charges. A CSNET connection using dialup was added in 1984, changed to X.25 in early 1985 [5]. The main applications in SDN were email including Korean language email, file transfer, virtual terminal, and USENET news. However, overseas links were restricted to email and limited news groups due to expensive overseas communications until the leased line Internet connection using TCP/IP was made between Korea and the U.S. as part of the Pacific Communications Network (PACCOM) Project in 1990 [9].

ASIANET

SDN was connected to North America (hplabs and seismo in USA, CDNNET in Canada), and Europe (mcvox in the Netherlands) from 1983. Computer network development for Asia was discussed during a UNESCO workshop in February 1984 [4]. AsiaNet with UUCP protocol was subsequently developed among Australia, Indonesia, Japan, Korea and Singapore.

The first AsiaNet meeting was held during the Pacific Computer Communications Symposium (PCCS) in October 1985, where it was decided to initially make indirect links via the U.S. between AsiaNet countries (Fig. 3). In the second AsiaNet meeting in September 1986 during the 5th International Academic NetWorkshop, it was decided to make direct connections among AsiaNet sites. The AsiaNet countries interconnected in 1987 included Australia, Indonesia, Japan, Korea, Singapore, Malaysia, and Hong Kong.

INTERNATIONAL COLLABORATION

International collaboration started from a USENIX Meeting in 1982 [10]. UUCPNET and USENET were discussed among delegates from Asia, Europe, and North America. As described above, this led to the development of the regional AsiaNet, in addition to links to Europe and North America.

In 1983, Korea participated in the second International Academic NetWorkshop (IANW) in Oslo [11] together with Australia and Japan. Korea, Japan, and Australia held the First International Academic NetWorkshop-Asia-Pacific Meeting (IANW-AP) one evening during the 1984 IANW in Paris. This was the first Asia-Pacific network meeting.

In February 1984, UNESCO organized a workshop on computer applications in Singapore, where Korea proposed AsiaNet to interconnect Asian universities. This proposal was realized the same year, and Australia and Japan, which did not participate in the UNESCO workshop, were also invited to join AsiaNet. Many countries in Asia that participated in the UNESCO Workshop were invited to PCCS (see below) in the following year where the first AsiaNet Meeting was held.

INTERNET CONFERENCE

In 1985, a symposium focusing on computer networks, the Pacific Computer Communication Symposium (PCCS) [2], one of the first global conferences on the Internet, was held in Seoul with approximately 300 participants from Asia, Europe, and North America. Considering that the next global conference on the Internet was held in the early 1990s, this symposium was an epoch making event that also displayed the active and leading role played by Korea in the global Internet field. In addition, PCCS provided the impetus for starting the Joint Workshop on Computer Communications (JWCC) from 1986. JWCC, a workshop for Asian computer network experts was held annually with the venue initially alternating between Japan and Korea. The list of participants expanded gradually, and evolved into the regional conference called the International Conference on Information Networking (ICOIN) [12]. The Annual Winter Computer Communication Workshop (WCCW) was also created for Korean domestic network experts in 1986.

RESEARCH AND EDUCATION NETWORK

CSNET [13] was created in 1981 by universities in the U.S. in close collaborations with ARPANET. CSNET offered universities and research institutes on other continents the opportunity to link to CSNET through IP-to-X.25 and dialup. Many countries in Asia including Korea connected to CSNET in the 1980s, forming a global computer network community along with IANW.

BITNET [14] was also created in 1981 for universities with IBM mainframe computers, offering leased line connections to universities outside North America. Good support from IBM enabled many countries in Asia including Korea to join BITNET in the late 1980s.

Many countries were also involved in OSI (Open Systems Interconnection) development. Many testbeds were developed around the world, and Canada made its EAN message system available to other countries. Several countries in Asia purchased this X.400 message system and deployed it for production service in their networks, including JUNET in Japan and SDN in Korea.

PACCOM PROJECT

In 1989, the University of Hawaii was the focal point of the PACCOM Project, connecting Australia, Hawaii, Japan, Korea, and New Zealand with funding from NASA and NSF in the U.S. as well as from other countries. In Korea, many member organizations of SDN agreed to join PACCOM with joint funding of the 56 Kbps leased line to Hawaii, and established an organization named HANA for this purpose. In March 1990, a SUN workstation at KAIST was connected to NSFNET through the University of Hawaii via a 56 Kbps satellite link, and HANANET was launched.

In the late 1980s, international connections to UUCPNET and CSNET were charged based on the number of X.25 data packets. International Internet connections were highly limited due to the expensive charges. However, after the establishment of the leased line connections to NSFNET through the University of Hawaii under PACCOM, people could use the international connections with relatively little limitation. Data traffic for Internet applications during this time was the highest for FTP, followed by Mail, Telnet, Archie, and DNS. In August 1992, the main gateway and the operation of the HANANET and SDN were transferred from KAIST to Korea Telecom (KT) Research Center. Thenceforth, HANANET of the KT Research Center assisted the development of KORNET, KT's commercial Internet services.

SDN was used to designate domestic networks and HANANET was used to designate networks connected to the global Internet after the construction of HANANET. The name SDN gradually lost recognition, and the Korean Academic Network Council (ANC) decided to phase out the use of the name SDN in 1993.

INTERNET COORDINATION

In the mid-1980s, there occurred a series of critical events which enabled the Internet in Korea to meaningfully participate in the global Internet. The first IP address, 128.134.0.0 was assigned for Korea by Internet Assigned Numbers Authority (IANA) in July 1986. A country code top level domain (ccTLD) to represent Republic of Korea (South Korea), .kr, began operation in 1986. The rules for the second and third level domains under the .kr domain were established, too. Subsequently, the second level domain names in five categories with two letters were set up; ac for academic organization, co for company, go for government, re for research organization, and or for non-profit organization. The computers in KAIST and other sites were registered as the domain name server for the .kr domain (for example, sorak.kaist.ac.kr), thereby establishing the infrastructure for allowing not only domestic but also international open access to the computers using .kr as their top level domain name. KRNIC was set up in 1993 to handle the administration of the .kr top level domain name, the IP address, and the AS number among others.

The coordination of Internet resources was done initially by the special interest group of SDN. Later, it became necessary to organize Internet coordination more formally, and the Academic Network Council (ANC) was created in 1991. ANC evolved to Korea Network Council (KNC) in 1995 as the commercial Internet service providers started their operations.

BROADBAND

NATIONAL BROADBAND PROJECT

The Korea Information Infrastructure (KII) project, the largest project in the history of Korean governments started with the 1995 master plan [3]. In the first stage between 1995 and 1997, optical networks were constructed among 80 urban centers, and an Asynchronous Transfer Mode (ATM) testbed network was built. In the second stage between 1998 and 2000, nationwide ATM network service started. The Internet backbone network located in major cities was upgraded to the B-ISDN rate of 622Mbps using the nationwide optical network. International lines were upgraded to 290 Mbps. By 2000, high-capacity and high-speed optical transmission networks were built in 144 regions in Korea.

While the government along with KT built a backbone network based on ATM switches, Thrunet, the first broadband

Internet service provider in Korea, built its backbone network based on Internet routers and the optical Ethernet in 1998. There were further debates on backbone switches between ATM and routers in the government and the major ISPs including KT and Thrunet. The Korean government along with KT decided to extend ATM switches and added an ATM-MPLS network in the third stage of Korea Information Infrastructure Project between 2001 and 2005 [23]. Other commercial ISPs built their backbone networks with the Internet routers.

INTERNET CAFE

In the late 1990s when demand for Internet services was increasing but Internet access from individual homes did not meet the demand, Internet cafes, or “PC bang” as it is called in Korea, began to appear. The first domestic Internet cafe was Netscape which began its operation in 1995. The number of Internet cafes rapidly increased, reaching 15,150 by the end of 1999 [17]. Many Internet cafe users became the first broadband service subscribers when broadband became available to residences in the late 1990s.

The number of online gamers also increased, with the Internet cafes at the center of this phenomenon. In 1998, an online war simulation game called Starcraft was widely played by the general public. A strong desire for online games by young people in their teens and twenties made broadband residential access popular.

BROADBAND INTERNET

Individual home users of the Internet had a maximum connection speed of only 64 Kbps (dialup service) until the late 1990s. However, this changed when Thrunet began to provide broadband Internet services in July 1998. It provided approximately 1Mbps connection speed using bidirectional cable TV networks [17]. Hanaro Telecom and KT offered broadband Internet provider services with Asymmetric Digital Subscriber Line (ADSL) in 1999. The cable modem and ADSL broadband service companies engaged in fierce competition for subscribers.

This intense competition brought down subscription fees, while providing better quality Internet access and additional services. Korea’s Internet service providers were charging one of the lowest monthly subscription fees in the world. For example, the total DSL downstream/upstream kbps per USD per month was 42.75~224.32 in Korea while 35.41 in Japan, 17.94 in the United States, and 11.96 in the U.K. as of Mar. 2001 [15]. This provided the main impetus for many people to subscribe to broadband services. Korea was the leading performer in the OECD countries. As of June 2001, Korea’s broadband penetration was more than double the next best performing country (Fig. 4) [15]. The number of home users with broadband Internet access exceeded 7.8 million [16]. The number of Internet users exceeded 10 million in 1999 and 26 million in 2002, more than half of the population in Korea. Internet banking was so convenient that more than 11 million users, about 30% of the population in Korea, signed up for Internet banking by November 2001.

Fiber-to-the-Home (FTTH) services started with 100 Mbps or higher data rate in 2006. The widespread availability of broadband Internet access services including FTTH, ADSL, and cable modem provided the momentum for Korea to become one of the most connected nations in the world [18].

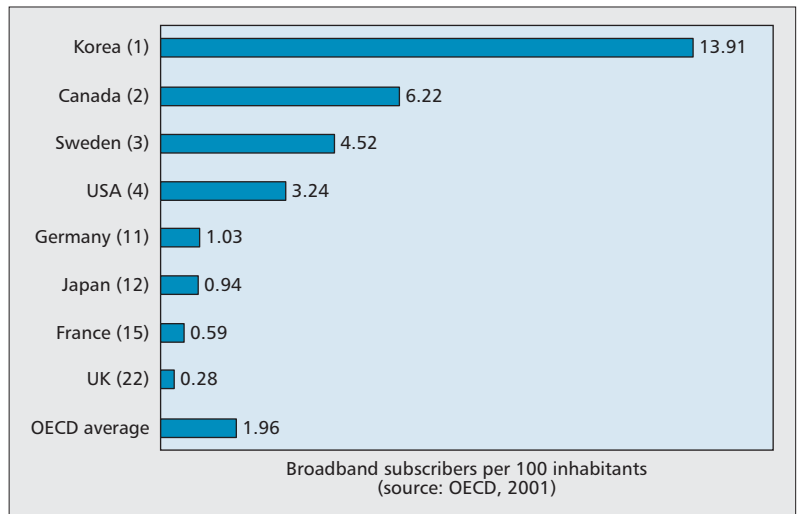


Figure 4. Broadband subscriber statistics as of June 2001 (source:OECD 2001 [15]).

This leap in the development of broadband Internet stimulated the expansion of various multimedia services. It paved the way to ubiquitous networking made possible by the convergence of Internet, broadcasting, and telecommunication. Later, broadband wireless Internet services were provided through mobile phones services and broadband data services including Mobile WiMax.

WIRELESS BROADBAND

Korea is one of the leaders in the wireless Internet market by being the first country in the world to introduce CDMA 2000 1x in October 2000. EV-DO was introduced in January 2002. Wireless Internet service via the mobile handset had limited universal applicability in the past due to its low data rate and high connection fee. Mobile WiMax, called WiBro in Korea was developed in Korea to provide high-speed mobile Internet service at an attractive price. In February 2002, the Korean government allocated 100 MHz bandwidth in the 2.3–2.4 GHz band for Mobile WiMax service, and ITU formalized Mobile WiMax as the IEEE 802.16e standard [19] in late 2005. WiBro service began in June 2006. It can offer up to 10 Mbps data rate per device, and cover a radius of 1–5 km, enough for wireless internet. It could provide mobility up to 120 km/h which is faster than WiFi, but slower than mobile phone technologies which have mobility up to 250 km/h or more.

Two out of three cellular mobile telephone service providers started WCDMA service in December 2003, providing voice, video, and high-speed data service at 2Mbps using mobile handsets. However, the data traffic did not fully grow because the mobile telephone service providers maintained expensive data traffic policies. WiFi modules were not available until smart phones were introduced in 2008. The introduction of the smart phone has led to an explosion of wireless Internet traffic. LTE services were launched in July 2011 to help overcome the access bottleneck.

COMMERCIAL INTERNET

With the global emergence of commercial Internet access services in 1994, a wide-variety of web-based commercial services also emerged. Internet World Exposition in 1996 helped to boost web-based services as well as the Internet ventures in Korea and other countries in the world [20].

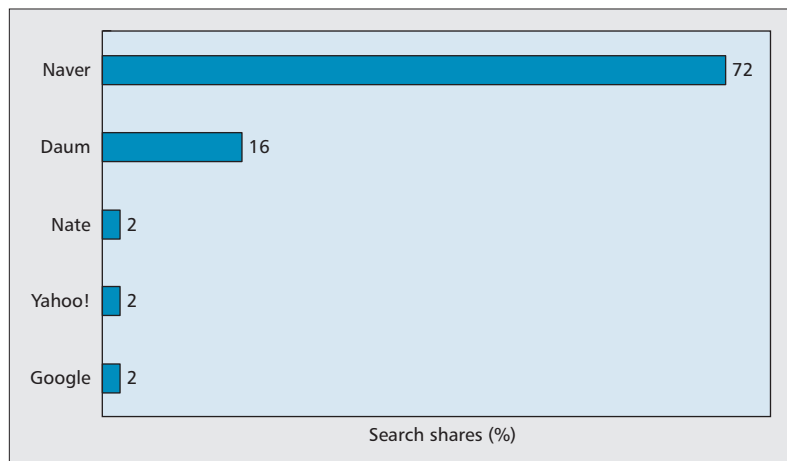


Figure 5. Top five search engines in Korea by query volume as of Sept. 2011 (source: aceCouter.com).

Initially, only simple duplicate services of the business model which had been proven in the USA were offered in Korea. These services included online newspaper services, directory services to guide through a number of emerging web services, the online shopping mall, Interpark, and the auction service, Auction. Web-based commercial service was initially dominated by Yahoo! Korea, which was established in 1995 as a joint venture of Yahoo! and TriGem.

The first web-based email service was Hanmail by Daum, which eventually grew into the first dominant search engine and portal, overtaking Yahoo! Korea around 2000. This trend of copying and localizing the USA-initiated web services continued and spurted along with the proliferation of the Dotcom era in the late 1990s and early 2000s.

However, the Korean web community was not satisfied with simple copying of the USA-initiated business model, and began to create new service models as well as new business models. Most notable was the invention of a business model of selling virtual items by SayClub [36]. This revenue model became the foundation of numerous online services and gaming. Also notable were the creation of an online gaming market, and the creation of social network services.

SayClub started as a web-based reincarnation of IRC-based chat, but became an instant success connecting online users in real-time chat. In 1997, SayClub started selling virtual items including personal avatars to symbolize the user's online identity, costumes to decorate those avatars and so on, and became an instant commercial success. This model started the now-common business model of "offering the commercial service for free, and selling virtual items needed to use the service better", so-called freemium services. The freemium service model has since become so ubiquitous, especially in online gaming, that a number of now-popular Internet businesses rely mostly on the freemium model, including Tencent and Zynga. This invention of the freemium model may be considered the most important invention of the Korean commercial Internet community, contributing to the global online service community.

Korea Internet game companies started a new market of online gaming, in particular in the Massive Multi-player Online Role Playing Game (MMORPG) category. Initially in 1994, a game called "The Land of Dangun (the progenitor of the Korean people)" in the RPG category became a huge success on then-popular PC online services. Inspired by the success of the game, several web-based online RPG games

including "The Kingdom of the Winds" and "Linage" were introduced, and created an over 5 billion dollar online gaming market in Korea in the following decade. This trend also created an over 20 billion dollar market for multi-player online games globally, mostly in East Asia market.

The first commercial success of the social network services was made by Cyworld, which started its service in 1999. Cyworld gathered more than 70% of the Korean population as its members, several years before the birth of Facebook. A search provider, Naver, made the first commercial success of an online Q&A service, called Jishik-In, which translates to "Knowledge Man", as part of its dominant search service. This helped Naver to become a 10 billion dollar search powerhouse in Korea (Fig. 5), and one of the ten most popular websites in the world.

These inventions and successes of the Korean commercial Internet community had a profound influence on subsequent commercial web-services globally by providing important business models for commercial services.

Today, 15 years after emergence of online commercial service in Korea, it has achieved an important position in Korea's economy. The overall size of the Internet-based economy in Korea is 63 billion dollars, which contributes about 6% to the Korea's GDP. Currently (in 2012), online services command the first or second positions in key categories of the economy. For example, online shopping takes about 11% of the retail market with about 34 billion dollar transaction volume. In the advertisement market, online advertising takes about 20% of the market, second only to TV advertising. We expect that this trend will keep evolving to make the overall economy rely even more on online commercial services.

RETROSPECTIVE

Korea was one of the pioneers of research and development on computer networks based on TCP/IP in the early 1980s, launching one of the first TCP/IP research networks in the world in the spring of 1982. As a developing country, Korea chose to focus more on the development and establishment of computer networks and systems than on fundamental research dominated by the global leaders. Nevertheless, Korea played a leading role in Internet research and development in several areas including search engine and services, online games, social network services, and wireless communication systems. Korea was also a leader in information infrastructure development including broadband networks, and in content and services.

The success in Korea of the Internet and its applications may be attributable to the foresight of researchers, policy makers, industry, and high technology entrepreneurs among others. On the other hand, Korea also experienced setbacks partly due to the lack of adequate experience and the lack of an adequate social system. For example, the SQL Slammer worm incident in 2003 brought down the entire Internet in Korea just as the Morris worm did in the U.S. in 1988, but did not cause as much damage in some other countries. Two of the major reasons for the 2003 Internet crash in Korea were homogeneity of the operating systems and inefficient incident handling systems. We also experienced many offensive Internet abuse incidents including personal attacks and serious privacy infringement compared with many other countries. We need to learn from these failures and mistakes.

Today, Korea is one of the leading Internet countries in the world, leading in some areas though lagging in other areas. We hope that Korea can share its Internet and other information technologies as well as the experience it has gained through their development and operation with other countries, especially developing countries, and collaborate with all countries to develop a future information infrastructure that harmonizes well with the global society and environment in which we live together.

APPENDIX: BRIEF DESCRIPTION OF THE INTERNET IN NORTH KOREA

The Internet has been available in Democratic People's Republic of Korea (North Korea) since the 1990s [21]. Research and development activities on the Internet and related areas started in the 1990s among the major research institutes and universities. Optical fiber cables were installed to connect most cities in the late 1990s. Access for organizations within cities uses ADSL and dialup. Various Internet and web applications are available today. Many universities have campus networks with digital library and other applications. Some of them collaborate with universities in Asia, Europe and North America. It is ironical that Republic of Korea (South Korea) was one of the first countries whose ccTLD, .kr, was delegated in the mid-1980s, and Democratic People's Republic of Korea (North Korea) was one of the last countries whose ccTLD, .kp, was delegated in 2007.

North Korea is one of those countries from which it is hard to get statistical data, as one can see in the Internet survey websites such as www.InternetWorldStats.com. We hope that more information becomes available in the future.

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BIOGRAPHIES

KILNAM CHON received his Ph.D at UCLA in 1974. After working at JPL, he moved to KIET, Korea in 1979 to pursue R&D on computer systems including computer networks, and led the team to develop the Korean TCP/IP network in 1982. He later moved to KAIST. He received the Jon Postel Award in 2011, the World Technology Award in 2003, two Presidential awards in Korea for information technology and mountain climbing.

HYUN JE PARK received his Ph.D. at KAIST in 1990. He was the SDN Network Manager from 1983 to 1990. He joined Thrunet Co. Ltd. as CTO in 1997, where he launched Korea's first broadband Internet commercial service in 1998. He is now Digital Television/Broadcasting Program Director of Korea Evaluation Institute of industrial engineering in the Ministry of Knowledge and Economy. He received the first Internet Technology Award of KRNK in 2000.

JIN HO HUR was a member of the team developing SDN, the first TCP/IP-based R&D network in Korea, from 1983 through 1990. He founded Inet, the first commercial ISP in Korea in 1994, and several startups since then. He is now Founder & CEO of Crzyfish, Inc, a mobile social game platform provider. He served as the 2003-2011 Chairman of the Korea Internet Corporations Association, Korea's primary industry association for Internet-related businesses. He received his Ph.D. from KAIST in 1990.

KYUNGRAN KANG received her Ph.D at KAIST in 1999. She worked as the editor of RFC-KR, the standards for Internet in Korea from 1998 until 2002. She joined Ajou University in 2004.