CHAPTER 6 Snapshots of the Internet around 1990

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Asia in this book covers the continents of Asia and Australia, and the western and southern Pacific. It is a diverse area comprising over four billion people, 57% of the world's population, and over fifty countries including the world's two most populous nations, China and India. It stretches from Russia in the North to New Zealand in the South, from Egypt in the East to small island states in the Pacific. In terms of the world's Internet user population, Asia surpassed one billion in 2011 – over 50% of the world's Internet users.

This book focuses on the countries that have led Internet development with a particular attention paid to the Asia. Chapter 6 is dedicated to snapshots of Internet activity around 1990 in many countries of Asia, as well as broad overviews of the four other continents in the world since the Internet is a truly global phenomenon with close collaboration among the five continents. In some cases, the snapshot article contributors have chosen to cover all of the 1990s and not just the period around 1990.

This chapter first presents the snapshots of individual countries in Asia and then turns to overviews of the four other continents.

6.1 Australia

Ian Peter

The story of the Internet in Australia in the 1980's is largely about the growth of the Australian Computing Science Network (ACSNET). It is only at the end of the decade that we see wider access provided, by the formation of the Australian Academic Research Network (AARNet), and by the earliest public access and commercial service providers, notably Pegasus Networks nationally and Dialix in Western Australia.

More on these initiatives later, but firstly to the beginning of the decade.

As Roger Clarke points out in his excellent Brief History of the Internet in Australia,

> "From the mid-1970s onwards, Robert Elz at the University of Melbourne, and Bob Kummerfeld and Piers Lauder at the University of Sydney ran the very successful Australian Computer Science network (ACSNET). For interstate links, ACSNET used the other major academic network in Australia at the time, the X.25based CSIROnet.
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> In the early 1980s, a permanent Australian email connection to the US ARPANET was established. This involved various contributions by (now Prof.) Bob Kummerfeld and Piers Lauders at the University of Sydney, and Prof. Peter Poole and Robert Elz at the University of Melbourne. In 1984, the Top Level Domain (TLD) .AU was delegated to Robert Elz, at Melbourne University. In the mid-1980s, Geoff Huston at ANU contributed an email gateway from the ACSNET mail delivery system into the DEC VAX/VMS systems that had come to dominate

University computer installations following their first implementation at the ANU's Mt Stromlo Observatory in 1978."

Email and news spread through Australian university and research communities in the mid1980's, although almost entirely in computer science and closely related areas. For much of academia, the primitive interfaces were difficult to handle for a generation of non-computer literate academics.

At this stage, conflicting protocols and lack of interoperability abounded among early users of data networks. Even within the academic communities, the DEC proposals for a regional SPEARNet (South Pacific Education and Research Network) advocated use of OSI rather than Internet protocols – a position also advanced by advocates for early government networks. Business users utilized proprietary systems developed by Telecommunications carriers or overseas services such as Compuserve, libraries used British Telecoms' data services, and amateur computer users utilized FidoNet, a PC-based network.

Additionally, a few Australians made spasmodic connections to the emerging Internet via the international dial-up service offered by the then Australian Overseas Telecommunications Commission (OTC). It was via this service that I personally got involved, originally providing connections to the Econet service in San Francisco, a Unix-based networking initiative connected to NSFNET, for the Lismore based Rainforest Information Centre. This led the United Nations Environment Program (UNEP) to provide funding in 1987 for connections to key environmental groups in Sri Lanka, India, Malaysia, Philippines, Nepal, Hong Kong and Japan. Although many of these connections failed due largely to lack of computer literacy, this became the basis of the work which led to the later creation of Pegasus Networks.

Back in academia, in 1987-88 a report (the 'Carrs Report') was prepared for the Australian Vice-Chancellors' Committee, proposing among other things the establishment of the Australian Academic Research Network (AARNet). Geoff Huston was transferred from the ANU to the AVCC in March 1989, as the initial technical manager of the network. He worked with Robert Elz, Robin Erskine and Ken McKinnon to prepare a financial, technical and business plan that was acceptable to the AVCC and its constituency. Approval to proceed was given in about May 1989.

AARNet positioned itself as a wholesale backbone Internet Service Provider (ISP). This encouraged smaller ISPs to emerge without the requirement for extensive capital investment in international and domestic infrastructure. This benevolent (but also financially sensible) strategy allowed the ISP population to grow rapidly, to the point where by the mid-1990s over 20% of AARNet traffic could be attributed to other providers.

Meanwhile, in June 1989 public access began to open up when Pegasus Networks began offering services to the general public in Australia, utilizing national x.25 networks (Austpac) to provide Australia wide access to Internet newsgroups, Internet email, and other services. Initially based in Byron Bay, NSW, Pegasus Networks provided a host service on a Unix-based server on a 386 computer – part of a project by Community Data Processing in the USA to provide low-cost Internet hosts. This project was an initiative of the Association

for Progressive Communications (www.apc.org), which by 1989 had established services in 7 countries (USA, UK, Canada, Brazil, Australia, Sweden, and Nicaragua) and from there proceeded to a range of initiatives to create low-cost Internet hosts across developing countries in all continents.

The Pegasus Networks services connected not only Internet email and newsgroups, but also to a variety of other emerging academic, commercial and non-profit networks and information sources, utilizing Internet protocols and a range of temporary gateway solutions to connect to legacy systems. The UFGate software developed by Tim Pozar in the USA allowed connectivity for Internet services to the Fidonet email services provided by computer hobbyists, and gateway services also existed to most major legacy proprietary email services. Early adopters of the Pegasus services include environmental groups, small business networks, the Australian Computer Society, and online learning enthusiasts. Although much of the early emphasis was on non-profit groups, Pegasus made it clear from the beginning that it was providing access for everyone who needed access to the Internet. Paul Wilson (later Director General of APNIC) became the first Technical Director and later CEO of this service, after it relocated to Brisbane to provide better connectivity. The official Pegasus launch in September 1989, utilizing dial-up via mobile networks, was covered by the ABC's 7.30 Report as recorded here (http://www.youtube.com/watch?v=HP_KrOUwdO0 &feature=email).

Late in 1989, Dialix also began to offer a simpler range of Internet services in Western Australia, utilizing STD dial-up services.

So, by 1 January 1990, Australia had fully fledged academic networks and the beginnings of wider public access. But with growing interest in what could be achieved through such communications, an explosion in usage was imminent. In 1992, there were just two public access services connected to AARNet (Pegasus Networks and Connect.com.au, started by Hugh Irvine and with a concentration on larger corporate networks). By 1995, with the additional catalyst of the World Wide Web, over 300 services were connected, and a mass migration of business and governmental users from legacy data services and non–Internet protocol services was underway.

6.2 Bangladesh

Hakikur Rahman

The first Internet service in Bangladesh was provided by Drik ICT that began operations as an offline Internet provider in 1992. Later on, the company extended its operations and began to offer commercial services starting in February 1994, registered as an ISP under the name DrikAlokchitraGranthagar Ltd. by the Bangladesh Telecommunication Regulatory Commission (BTRC). In 2011, their license was upgraded by BTRC enabling Drik ICT to provide both Internet and data communications services nationwide.

A VSAT base data circuit was commissioned for the first time in the country on 4 June 1996. At that point, another ISP, the Information Services Network (ISN) Limited,

started offering its first Internet on-line services on 6 June 1996 through a 64 Kbps VSAT transmitting and receiving data via a gateway in Hong Kong. In 1997 and 1998, the company consolidated its operations to achieve a higher professional standard. In 1999, they signed a joint venture agreement with a foreign partner. Currently, ISN is a public limited company, trading on the stock exchange since 19 May 2002.

After the introduction of VSAT-based Internet, the use of email increased exponentially. However, prior to its availability, dial-up services were used by existing ISPs to send and retrieve international mail through international phone calls using the UUCP protocol. Until mid-1996, services were provided by only the two ISPs above and the client base was not broad. However, in 1997, the number of customers grew dramatically as more ISPs began providing services.

The lone Internet exchange, BDIX, started operations as a not-for-profit organization on 1 August 2004. After the country was connected with an SEA-ME-WE4 submarine line in May 2006, Internet penetration grew even further as the cost of Internet services dropped dramatically, due to government policy and advocacy on behalf of civil society.

6.3 China

Hu Daoyuan

On 25 August 1986 at 11:11:24 GMT, Wu Weimin, using an IBM PC at Institute 710 at the Chinese Academy of Sciences Institute of High Energy Physics in Beijing logged in remotely via satellite link to Shuqin's account on VXCRNA at CERN Geneva and sent an email to Geneva-based Steinberger.

In September 1987, with the support from a scientific research group led by Professor Werner Zorn of Karlsruhe University in Germany, a working group led by Professor Wang Yunfeng and Dr. Li Chengjiong set up an email node at ICA and successfully sent an email to Germany on 20 September. The title of the email was "Across the Great Wall we can reach every corner of the world."

From 9-11 November 1987, a Chinese delegation was invited to participate in the Sixth International Academic Workshop held in Princeton, NJ, USA. During the conference, the local organizer presented a congratulatory letter from the US National Science Foundation (NSF) to the Chinese representative, Mr. Yang Chuquan, congratulating his group on the extension of BITNET and CSNET electronic mail to China.

In early 1988, China's first X.25 PAC, CNPAC, was established. Major cities covered included Beijing, Shanghai, Guangzhou, Senyang, Xian, Wuhan, Chengdu, Nanjing, and Shenzhen.

In March 1988, the China Academic Net (CANET) project was launched with the objective of organizing Chinese universities and research institutes to connect their mainframe computer to global computer networks.

In July 1988, using the satellite links of Radio Austria, the Institute of High Energy Physics of the Chinese Academy of Sciences implemented an X.25 protocol and connected one of its VAX 780 computers as a node on the European Organization for Nuclear Research (CERN) in Geneva, Switzerland.

In December 1988, the local network of Tsinghua University was connected to the University of British Columbia (UBC) through an X.25 network and enabled email exchanges through an X.400 protocol link set up by Prof. Hu Daoyuan of Tsinghua University.

In May 1989, the Chinese Research Network (CRN) was connected to the German Research Networks through a pilot X.25 network. Members of CRN included: the No. 15 Institute of Electronic Science of the Ministry of Electronic (in Beijing), the No. 30 Institute of the Ministry of Electronics (located in Chengdu), the No. 54 Institute of the Ministry of Electronics (located in Shijiazhuang), Fudan University, Shanghai Jiao Tong University, and Southeast University (located in Nanjing), among others. Services that CRN could provide included email (X.400 [MHS] standard), file transmission (FTAM standard), electronic directory services (X.500) and so on. People could also access the Internet through the DFN gateway in Germany.

In October 1989, one of credit projects of the World Bank – the Demonstration Network for Education and Scientific Research in Zhongguancun Area (as it was called by the State Development Planning Commission), or National Computing and Networking Facility of China (or NCFC, as it was called by the World Bank) prepared for implementation. It was then formally launched in November. NCFC was a high-tech information infrastructure project of the "Key Subject Development Project" of the World Bank, and was invested in and supported by the State Development Planning Commission, CAS, the National Natural Science Funds and the State Development Planning Commission. CAS was responsible for the project, and it was jointly implemented by Peking University and Tsinghua University. The chief goal of the project was to complete the construction of the NCFC backbone network and the college networks through technical cooperation with Peking University, Tsinghua University and CAS.

On 28 November 1990, with Professor Wang Yunfeng and Professor Werner Zorn's efforts, the registration of China's country code top-level domain, .CN was completed with Mr. Qian Tianbai as the administrative contact. From then on, China had its own Internet identity. Since China had not yet achieved full functional connection to the Internet at the time, the .CN ccTLD name server was temporarily set at Karlsruhe University in Germany.

In March 1991, the Institute of High Energy Physics of Chinese Academy of Sciences established a connection to the computer network of the Stanford Linear Accelerator Center (SLAC).

In June 1992, the '92 INET Conference was held in Kobe, Japan. There, Prof. Qian Hualin made an appointment with the head of the International Network Department of the US National Science Foundation to discuss the issue of the official connection between China and the Internet. However, he was informed there were political obstacles since so many US government departments were connected to the Internet.

At the end of December 1992, Tsinghua University Network (TUNET) was set up and went into service. TUNET was the first college network to adopt the TCP/IP structure in China. The backbone successfully adopted the FDDI technique for the first time, which contributed to many aspects of China such as the scale, the technical level, and the application of networks.

In the latter part of 1992, construction of the College Network (i.e. CASNET, which connects over 30 research institutes in Zhong Guan Cun area and CAS headquarter in San Li He) of Project NCFC, TUNET (Tsinghua University Net) and PUNET (Peking University Net) was completed.

On 2 March 1993, a 64 Kbps DECNET fixed line to the Stanford Linear Accelerator Center (SLAC) was officially launched. Built by the Institute of High Energy Physics of Chinese Academy of Sciences, the fixed line was operated by renting international satellite channels of AT&T. With great support from the National Natural Science Foundation of China, key researchers in various disciplines were able to use this fixed line through dial-up connections.

An email system was available to hundreds of domestic scientists.

On 12 March 1993, deputy premier Zhu Rongji proposed and launched the National Public Economic Information Network project (i.e., Golden Bridge Project).

In April 1993, the Computer Network Information Center, Chinese Academy of Sciences called some of the network specialists in Beijing together to investigate the domain name systems of each country, and then decided upon the domain name system of China.

In June 1993, experts of NCFC reiterated China's request to be connected to the Internet at the '93 INET Conference and discussed the issue with members of the global Internet communities. After the meeting, researcher Qian Hualin attended the CCIRN (Coordinating Committee for Intercontinental Research Networking) Meeting and won the support of the majority of participants to establish an Internet connection to China. The conference gave a great boost to China's connection to the Internet.

On 27 August 1993, Premier Li Peng approved the use of the Premier Reserve of 3 million USD to support the Golden Bridge Project to initiate its prophase construction.

On 10 December 1993, the National Joint Conference on Economy Informationalizing was formed. Zou Jiahua, the Deputy Premier of the State Council, was appointed the chair.

In December 1993, the backbone network construction of NCFC was completed. It connected three universities by high-speed optic cable and routers.

In early April 1994, the Sino-American Federation of Scientific and Technological Cooperation Committee held a meeting in Washington, D.C. Before the meeting, on behalf of China, the academician Hu Qiheng, the vice-president of the Chinese Academy of Sciences, reiterated to the National Science Fund (NSF) China’s request to be connected to the Internet. The proposal was approved. On 20 April 1994, the NCFC project began operating a 64 Kbps international dedicated line to the Internet through Sprint Co. Ltd of the United States, which completed China’s fully-functional connection to the Internet. Since then, China has been

officially recognized as a country with full functional Internet accessibility. It was chosen as one of China's top 10 scientific and technological events in 1994 by the Chinese press community and designated as one of China's key scientific and technical achievements in 1994 by the State Statistical Communiqué.

On 15 May 1994, the High-Energy Physics Research Institute – CAS – set up China's first web server and made the first set of web pages. Apart from a briefing on the development of high technology in China, there was another topic called "Tour in China." Since then, the site has expanded its range to information about current news, economies, culture and business and provided essays together with pictures and was renamed "Windows of China" afterward. On 21 May 1994, with the assistance of Professor Qian Tianbai and Karlsruhe University (Germany), the computer network information center of CAS finished setting up the China's top domain name (CN) servers, after which the .CN domain name servers were no longer located abroad. Qian Tianbai and Qian Hualin were the administrative contact and the technical contact respectively. Again in May 1994, the National Research Center for Intelligent Computing System opened the first BBS in Chinese mainland – Dawn BBS.

On 8 June 1994, the general office of the State Council issued the "General Office of the State Council's Notice on the Related Issues of 'Three Golden Projects' ". From that day on, the prophase construction of the Golden Bridge Project was fully underway.

On 28 June 1994, with the help from Tokyo University of Science, Beijing University of Chemical Technology began the pilot test of the leased line connection with the Internet. In early July 1994, the six-college-established (mainly by Tsinghua University) trial network "China Education and Research Network" began its operations. By using an IP over X.25 technique, it became a TCP/IP-based computer network connecting Beijing, Shanghai, Guangzhou, Nanjing, and Xi'an, and also connected to the Internet through the international port of NCFC.

In August 1994, China Education and Research Network (CERNET) project was officially launched with the aim of connecting college computers and sharing resources by using advanced computer and network communication technologies. Furthermore, it planned to connect with international learning networks and establish a full functional administrative network system. The State Development Planning Commission was the investor in the project and the State Development Planning Commission charged with carrying it out.

In September 1994, the Directorate General of Telecommunications P & T and the Department of Commerce of United States signed an agreement on the Internet connection. Under the agreement, the Office of Telecommunication would open two 64 Kbps leased lines (one in Beijing, the other in Shanghai) with the assistance of the Sprint Corporation in America. It marked the start-up of the CHINANET.

In November 1994, the Administrative Commission of NCFC hosted the annual meeting of the Asia-Pacific Networking Group (APNG) at Tsinghua University with the assistance of CAS, Peking University, and Tsinghua University. It was the first International annual meeting of the Internet community in Asia-Pacific region held in China.

In January 1995, the Directorate General of Telecommunications P & T, China Telecom began operation of the Beijing and Shanghai 64 Kbps leased lines to the United States with the help of Sprint Co. Ltd. It began to provide Internet access services through telephone networks, DDN leased lines, and X.25 networks.

In January 1995, "Chueng Kong Scholars" (Chisacm), the journal published by Ministry of Education (State Educational Committee), was put on the Internet through CERNET, focused on providing information to students abroad. It was the first Chinese E-journal in China.

In March 1995, CAS completed the long-distance connection to its four branch institutions in Shanghai, Hefei, Wuhan, and Nanjing with IP/X.25 technology. This marks the first step in China's project to spread the Internet connection to the whole nation. That same month, Professor Li Xing from Tsinghua University was elected the Executive Committee member of the Asia-Pacific Network Information Center (APNIC) for the first time.

In April 1995, Chinese Academy of Sciences (CAS) launched the project of connecting its institutes outside Beijing (known as the "100 CAS Institutes Connection Project"). The objective of the project was to expand the institute network (connected over 30 institutes of CAS in Beijing) to 24 cities all over the country, in order to realize the full connection of all domestic learning institutions and the connection with the Internet. Based on this project, the network expanded continuously, and was gradually connected with many scientific academies and researching outside CAS. It became a scientifically-oriented national network, serving scientific users, research branches, and relevant governmental departments. Its name was also changed to "China Science and Technology Network" (CSTNet).

In May 1995, the China Telecom began to prepare for building up the national backbone network for CHINANET.

In July 1995, China's first 128 Kbps leased line connecting with the United States was launched by CERNET; meanwhile, CERNET also opened DDN channels for its backbone network, connecting with eight cities-Beijing, Shanghai, Guangzhou, Nanjing, Shenyang, Xi'an, Wuhan, and Chengdu. The connection speed was 64 Kbps. The NCFC connection was also completed.

In August 1995, the primary phase of the "Golden Bridge Project" was completed. It completed the connection (through the satellite network) with twenty-four provinces and cities all over the country, and it further connected to the Internet.

In December 1995, the "100 CAS institutes connection project" was completed. That same month, the "CERNET demonstration project" was completed. This project was designed and constructed wholly by Chinese engineers.

In January 1996, the Informatization Leading Group of the State Council and its executive office were established. Zou Jiahua, the deputy premier of the State Council, lead the group. The former office of National Economic Informatization Joint Meeting was renamed the Office of Informatization Promotion Leading Group of the State Council. In January 1996, construction of the CHINANET backbone network was completed and began to provide network services throughout the country.

On 1 February 1996, the State Council issued "The Interim Regulations of the People's Republic of China on the Management of International Networking of Computer Information". On 27 February 1996, the China International E-Commerce Center of China International Electronic Commerce Center was formally established.

In March 1996, Tsinghua University proposed "the Unified Transmission Standard for Chinese Character Coding" to IETF, which was approved as RFC1922. This was the first Chinese proposal to be approved as an RFC document.

On 9 April 1996, the Ministry of Posts and Telecommunications issued "Rules for Administration of China's Public Computer Networks and International Connection", effective as of that day.

On 3 June 1996, the Electronics Industry Administration published "The Relevant Decisions on Administering the International Connection of Computer Information Networks."

In that document, "China GBN" was renamed the "China Golden Bridge Information Network".

It also accredited Jitong Communication Co. Ltd., the inter-connecting organization of China Golden Bridge Information Network, which was responsible for managing the connection of domestic organizations and users.

In July 1996, the Information Office of The State Council called specialists from relevant institutions to investigate the techniques then implemented and to discuss the administrative situations of the four major networks and nearly thirty ISPs in China. The investigation facilitated the standardization of network administration.

On 6 September 1996, the China Golden Bridge Network (China GBN) opened a 256 Kbps leased line connected to the United States. China GBN also announced the decision to provide Internet access service for institutional users mainly through dedicated lines and for individual users through telephone lines. On 22 September 1996, the first domestic City Area Network (CAN)-Shanghai Hotline started its test run, which marked the accomplishment of the Shanghai Public Information Network – the main structure of Shanghai information port project. Also in September 1996, the State Development Planning Commission formally approved starting the first stage project of “the Golden Bridge”.

In November 1996, CERNET opened the 2 Mbps international line connecting to the USA In the same month, during the German President's visit, CERNET opened the learning network between China and Germany – CERNET-DFN, which was the first Internet connection to Europe from the Chinese mainland. As well, on November 15, 1996, the Shihuakai Corporation opened the Shihuakai Internet Café beside the capital gymnasium; this was the first Internet café in China.

In December 1996, the China Public Multimedia Communication Network, known as Net 169 began its operation. As a preliminary group of connected websites, Guangdong Shi Ling Tong, Tianfu Hotline and Shanghai Online were officially opened.

This article was written based on the “Internet Timeline of China, 1986-1996” by CNNIC, Jan. 2004 [CNNIC 2004].

6.4 Hong Kong

Nam Ng

(1) Introduction

Similar to many parts of the world, computer networking in Hong Kong began in the 1980s in the universities, invariably in the computer science/engineering departments in conjunction with the computer centers that played a supporting role to the administrative offices which handled student registration, staff payroll, and ledger applications. The most popular computer systems for providing administrative applications in Hong Kong universities in the mideighties were the IBM computer systems that supported the Binary Synchronous Communications (BSC or Bisync) network protocol, while the most popular teaching/research systems were initially PDP and VAX computers from Digital Equipment Corporation (DEC) that supported the DECNET protocol and, later on, SUN Microsystems computers that adopted the Unix operating system and the UUCP network protocol as well as TCP/IP network protocol.

(2) UPCC and HARNET

In Hong Kong, inter-computer-networking among campuses started around 1985. The intercampus networking in the computer centers was facilitated by a group called the University and Polytechnic Computer Centre (UPCC), which consisted of five academic institutions at the time: the University of Hong Kong (HKU), the Chinese University of Hong Kong (CUKJ), the Hong Kong Polytechnic (HKP), the City Polytechnic of Hong Kong (CPHK), and the Baptist College, Hong Kong (HK Baptist). In late 1985, Dr. Nam Ng led a network group at UPCC to connect the PDP computers in the computer centers. He also coordinated the work with Dr. Kam-Pui Chow of the HKU Computer Science Department who had started a UUCPconnected network to form the Hong Kong Academic and Research NETwork (HARNET).

(3) Connecting HARNET to CSNET

The initial HARNET network mainly supported electronic mail and file transfers and served to connect the DECNET-connected computers with the UUCP-connected computers in the university and polytechnics. The HKU Computer Science department also set up various gateways to provide international dial-up connectivity to other parts of the world, including connections to ARPANET, Usenet and CSNET in the USA, ACSNET in Australia, JANET in the United Kingdom, CDN in Canada, and SDN in South Korea, etc. Additional applications introduced at that time included Usenet news.

(4) Connecting HARNET to BITNET

In June 1987, a proposal was made to join BITNET (Because It's Time NETwork), in order to provide network connectivity for the administrative systems that were supported by the BSC protocol. The connection was finally established in November 1989. The initial network link was a 2400 bps leased line connecting HKU with Yale University in the United States, making possible the connection of HARNET to BITNET. Protocol converters/emulators were used in the DECNET-connected and UUCP-connected computers to support the BSC protocol. Although not a high-speed link, it was considered to be a major investment by the universities at the time. This nevertheless provided network connectivity in real-time among the various popular computer platforms in the universities during that period.

(5) Email and file transfer in Chinese

As Chinese was one of the official languages of Hong Kong, there was a genuine need to support electronic mail and file transfers in the Chinese language, especially in our correspondence with China. One interesting development to record was the effort taken to investigate various methods of electronic communication using Chinese characters. As the most popular communications code was 7-bit ASCII code at that time, it was necessary find a way to allow Chinese character communications using the ASCII code. In response to this urgent need, Drs. JT Yu and N. Ng of the HKU Computer Centre and Professor Francis Chin and Dr. KP Chow of the HKU Computer Science Department cooperated with Professor Xu Kung Shi, Dr. Zhang Dawei and Dr. MC Pong of Academia Sinica and secured a research grant from the Croucher Foundation in Hong Kong to undertake some research investigations into the issues of communication using Chinese characters in those early days over slow network links.

(6) Connecting HARNET to the Internet

The first permanent link using the TCP/IP protocol in Hong Kong was established by the Faculty of Engineering of the Chinese University of Hong Kong (CUHK) in September 1991. With support from PACCOM, a 64 Kbps leased circuit was set up by CUHK to connect that network to the Internet in the United States. CUHK generously allowed other UPCC institutions to share the use of the link, and this made possible the initial connection of HARNET to the Internet. In July 1992, the CUHK Faculty of Engineering transferred management of the Internet link to UPCC. With the support of the University and Polytechnic Grants Committee which financed the Internet link, UPCC decided to open up the use of HARNET to all students, including undergraduates, of the academic institutions in Hong Kong as a means of exposing students to this new electronic environment for learning support over the Internet and the Information Highway.

(7) Commercial Internet and registration of '.HK' domain name

The opening-up of the Internet to student use in 1992 met with instant success in the academic sector in Hong Kong. This encouraged private enterprise to set up companies to

serve as Internet Service Providers in order to offer the Internet on a commercial basis to the Hong Kong community. UPCC then began to provide a registration service for .HK top level domain names. CUHK was also quick to set up the Hong Kong Internet Exchange (HKIX) to provide a local exchange point for supporting local and international connectivity to the Internet. At the same time, HARNET had started to provide international Internet connectivity for academic users in China (CERNET) and Macau.

6.5 India

Srinivasan Ramani

The Government of India, assisted by the United Nations Development Programme, launched the Education and Research Network (ERNET) project in 1986. The project funded research and development at eight collaborating institutions: the National Centre for Software Technology (NCST); Department of Electronics (DOE), government of India; five Indian Institutes of Technology; and the Indian Institute of Science. The eight coordinators were: Anurag Kumar, B.N. Jain, S.L. Maskara, S.L. Mehndiratta, S.V. Raghavan, S. Ramakrishnan (project coordinator from DOE), S. Ramani, and K.R. Srivathsan. This project carried out research (documented in over 150 papers and five books) and went on to create India's first nationwide computer network with international connectivity, serving Indian researchers and academics.

ERNET started UUCP email exchanges between NCST and IIT Bombay in 1986-87 and established TCP/IP connectivity between major cities in 1988. A TCP over X.25 connection was the first international link, set up in 1987. This connected India to the Internet through a router at CWI in Amsterdam. A TCP/IP link was commissioned to UUCPNET's gateway in Falls Church, MD, in the United States in 1988 using a dial-up link that worked round the clock. This dial-up link was replaced by an analog leased line in 1989.

Inter-city connections within India took a major step forward in 1988, starting with leased lines connecting the ERNET Centre in Bombay with ERNET centers in Delhi and Madras. Links to other cities followed soon after. Initial use of these leased lines was for running UUCP, and in a year or two, the intercity leased lines of ERNET offered high enough bandwidth to run TCP/IP within India.

The 1990s saw the introduction of higher bandwidths for computer networking, beginning with the commissioning of a 64 Kbps digital leased line between the ERNET Centre at the National Center for Software Technology (NCST), Bombay and UUCPNET, Falls Church, VA, USA, in 1992. The bandwidth used for Internet access expanded at an exponential rate over the years. The '90s also saw the introduction of VSATs with IP interfaces for routine Internet access from institutions in small towns and rural areas. ERNET pioneered the use of this technology, installing a major satellite communication hub in Bangalore in 1993 with the cooperation of Software Technology Parks of India, along with VSATs in dozens of educational institutions in remote areas. This technology remains relevant to this day (2012), with ERNET continuing to expand its VSAT network.

ERNET made a major contribution to the development of human resources, educating engineering students in large numbers. Institutions participating in ERNET gained valuable experience that contributed to the economy. Over a dozen Ph.D. dissertations and a large number of Masters' theses in networking technology came out during the nineties. The students involved went on to work in companies and other institutions, spreading the expertise.

When the first international connection was set up in 1988, NCST had been asked to serve as the domain registrar for issuing domain names to other institutions in India. ERNET was allotted the Class B IP address 144.16.0.0 by InterNIC in 1990. Subsequently, Class C addresses were allotted to ERNET by APNIC. ERNET continued to handle this domain registration function for all Indian users until 2004 and continues to handle registrations for 'AC.IN' and 'RES.IN' domains to this day. An autonomous entity funded by the government of India was set up in 1998 to carry on with ERNET activities. A new terrestrial high-speed backbone for ERNET was set up in 1999-2000. ERNET now serves over 1300 institutions.

A commercial service offering TCP/IP connectivity to the world was introduced by a company, VSNL Ltd., in 1995; VSNL was a government-owned company at that time. Major developments followed soon after this, due to deregulation in the telecom sector. The Telecom Regulatory Authority of India was created in 1997, and private Internet Service Providers were licensed starting in November 1998. There were 315 ISPs by 31 March 2000. The number of Internet access subscribers was only a little over 366,000 at that time. It is worth noting that broadband access to the Internet for individual consumers did not become available in India during the nineties. The tremendous growth in Internet usage after 2000 is a different story to be told elsewhere!

The first mobile telecommunications service was started in 1995. It was believed that there would be widespread Internet usage over the cellular network, but it must be said that the percentage of Indian cell phone users who were using their cell phones for Internet access remained quite small until the year 2000.

The Internet has enabled and supported the growth of the software industry in India. Software development and IT enabled services have grown rapidly, making a significant contribution to India's economy.

6.6 Iran

Siavash Shahshahani

As in many other countries, Internet activity in Iran began in academia. The Institute for Studies in Theoretical Physics and Mathematics (IPM) was established in Iran in 1989. One goal of IPM was to facilitate international communication between Iranian scientists and the international scientific community. To this end, IPM intended to provide email services for its researchers, a tool that was becoming ubiquitous as a vehicle for international academic communication. On 1 January 1993, IPM officially joined the European Association of Research Networks (EARN), a BITNET-based network of universities and research centers,

after completing a trial with a dial-up connection that began in the fall of 1992. The original link was a 9.6 Kbps leased line between IPM and the University of Vienna in Austria. It soon became apparent to IPM technical staff that a migration to a new protocol, TCP/IP, which was sweeping the networking world was required, and by early 1994 a TCP/IP connection was added to the existing NJE/BITNET network.

By early 1994, a number of universities and research institutions in Iran were linked to IPM to form IRanian Academic NETwork (IRANET). Until April 1994, Internet addressing in Iran was provided by the University of Vienna as a sub-network of that university. After overcoming early resistance by the United States National Science Foundation, then overseeing the Internet, IPM was granted the authority to operate with the 'IR' country code TLD as the official NIC of Iran on 6 April 1994, by InterNIC operated by Jonathan Postel. Registrations under .IR were then permitted only under one of four second-level domains AC.IR, CO.IR, NET.IR, and OR.IR, with the great majority of early registrations by academic institutions under the AC.IR subdomain.

Even in the absence of World Wide Web and the graphic Internet, it was apparent quite early on that one or a few leased lines could not possibly satisfy the ever-increasing demand for Internet communication by the academic sector alone. Ironically, early attempts by IPM to upgrade the capacity were stymied by two opposing forces. On the one hand, the governmental Telecommunications Company of Iran, which was the Iranian signatory to Intelsat, did not authorize IPM to use an Intelsat satellite which would have provided ideal coverage for service to Iran. On the other hand, other private satellite companies operated by United States companies were prevented by political pressure in the USA from providing such services to IPM. Finally in July 1996, an Italian company, Archway S.r.l., using a transponder on the
Eutelsat satellite, provided the first satellite connection to IPM and Iran, a 128 Kbps link to the UUCPNET backbone in Amsterdam. This was followed by upgrades of 512 Kbps, 2 Mbps, and similar connections to other Iranian entities, both governmental and non-governmental, and a new era of Internet use was thus ushered in.

Early attempts to expand the use of Internet in Iran, even for academic purpose, were marred by frustrating difficulties arising both domestically and from abroad. The Iranian Ministry of PTT, later re-named The Ministry of Telecommunications and Information Technology, used to its traditional monopoly and at one time keen on developing its own X.25 network, treated IPM as an unwelcome nuisance. Even acquiring antennas and other receiving equipment proved significant legal and logistical challenges for would-be providers such as IPM. On the foreign front, some over-zealous officials of the US government, acting beyond the then-existing sanction levels occasionally attempted to hamper Iranian connection to the Internet. A well-known case occurred in the summer of 1996, when an NSF employee threatened to sever a USA-European connection to European backbone EBONE, partially funded by NSF, which carried Iranian Internet traffic. As a result, Iran's traffic was cut off for two weeks but was finally restored after protests initiated by IPM and widely supported by the international community, including various US bodies and individuals. A fortuitous

outcome of this event for Iran was the granting of an AS (autonomous system) number to IPM by RIPE NCC–the first to an entity in Iran–as the Europeans were no longer willing to shoulder responsibility for Internet traffic with Iran in view of possible future US intervention.

6.7 Japan

Haruhisa Ishida

The first Internet-compatible computer network in Japan, called Japan University Network (JUNET), was established in 1984, and was based on the UUCP protocol that offered an Internet-compatible email service. It connected many university sites as well as those in the private or governmental sectors in Japan. It also linked to overseas sites in the USA, Europe, and Korea among others. Eventually, there were 700 organizations connected to JUNET by 1990.

The Widely Integrated Distributed Environment (WIDE) Project was founded in 1988 after its predecessor, WIDE Research Group, began its operation in 1985. The WIDE Project led various Internet initiatives in Japan including the establishment of .JP as the country code Top Level Domain (ccTLD) as well as coordinating IP address allocation in the mid-1980s. This led to the establishment of JNIC in 1991. JNIC was renamed JPNIC in 1993 and became a private organization. JPNIC in turn hosted the initial trials of APNIC, the Regional Internet Registry (RIF) for the Asia-Pacific region, from 1993 until APNIC became an independent organization in 1994.

The WIDE Project also worked on research and development networks including, notably, the PACCOM Project, which was led by the University of Hawaii with funding from the National Science Foundation in the USA with additional funding provided by each PACCOM member country including Australia, Hong Kong, Japan, South Korea, and New Zealand. The PACCOM Project collaboration led to the establishment of Japan-USA links for the WIDE Project as well as the creation of NACSIS through the University of Hawaii in 1989. NACSIS was renamed the Science Information Network (SINET) in 1992. There were also a few more networks including the High Energy Physics Net, Japan (HEPnet-Japan) in Japan that had overseas links.

Japan hosted the second INET conference in 1992 in Kobe with over one thousand participants from around 100 countries around the world. It was a very successful Internet conference and was organized by the newly established Internet Society (ISOC). The second one-day developing country workshop was also held with great success, so it was decided to expand from a one-day to a one-week workshop.

The first commercial Internet service provider also appeared in Japan, called the Internet Initiative Japan Inc. (IIJ), after the first commercial Internet service providers opened for business in the USA and Australia in 1989. IIJ was a spinoff of the WIDE Project, and

many more Internet service providers appeared in the1990s, including ones run by telecommunications service providers such as NTT and KDDI.

The IP Meeting was founded in 1990, later to be renamed Internet Week. This was a gathering of various Internet organizations in Japan to discuss the operation, engineering, and administration of the Internet. In 1994, InterOp expanded its successful operation of conferences and exhibitions in the USA to Japan under the names Networld & InterOp. They became some of the largest Internet conferences and exhibitions in the world.

The Kobe area was hit very hard by a major earthquake in January of 1995. Practically all means of communication were destroyed, but the Internet was still functioning minimally and contributed to sustained communications through email. From then on, Japan took a very active role in the use of the Internet in disaster situations.

In 1996, the Internet Exposition was held around the world in over forty countries, and Japan took a very active role, hosting many virtual events using the Internet itself as well as several physical events including the closing ceremony of the Internet Exposition.

This article was written based on the Chronological Table in History of Internet in Japan of History of WIDE Project for 10 Years [WIDE 1999; Chon 2013c].

6.8 Kazakhstan

Bakhtiar Buleshev

To support the activities undertaken by the Institute for Problems of Informatics and Management of the National Academy of Science of Kazakhstan (IPIM NAS RK) for the creation and implementation of new information systems and networks, a telecommunication node was established to provide for the information demands of the institute.

This center had a node IAS-NET-A on an X.25 packet-switched network and implemented the technology of the ideal model of interaction on open systems. The center provided access to practically all the networks and large information centers (including VINITI, MTsNTI, GPNTB, GBL, and VIMI) of the present-day CIS states as well as foreign networks. Today in the republic, such technology is implemented only on the SPRINT network.

This access point provided the opportunity for groups of highly-skilled experts to work out and implement technology to provide integrated access to users of information resources of various types and was a solid enough technical base for that period of time. It also gave researchers the opportunity to experiment with their own ideas on how to serve users of the center.

Unfortunately, the situation in 1994 was such that the telecommunications node was used inefficiently due to a number of reasons, the main of which was the insufficient funding for telecommunications lines and information resources.

At that time, the only point of network access for our institute was the RELCOM network of which it was a subscriber. There was also guest access to several other X.25

networks such as IASNET, ROS-NET, and ROSPAC using an Iskra-2 line. Many institutes of NAS RK, especially of natural sciences, were also subscribers to the RELCOM network.

In 1993, an agreement was signed in the republic on establishing a republic-wide computer network for information exchange and work was begun that same year. To that end, a joint stock company, Kzinformtelecom, was founded. The founders of that company were the Ministry of Science and New Technologies of the Republic of Kazakhstan as well as a number of enterprises.

In 1993, an agreement was signed and in that year work begun on establishing a republicwide computer network for information exchange. For this purpose the joint stock company "Kazinformtelecom" was established. The founders of this joint stock company were the Ministry of Science and New Technologies of the Republic of Kazakhstan as well as a number of enterprises of Dzhezkazgan involved in the mining and export of non-ferrous metals. Thus, the network had a twofold purpose: first, to serve the department of the State Institute for scientific research information (KazGosINTI) which operated in the nineteen regions of Kazakhstan, the national research centers of NAS RK; and, second, to serve commercial users.

The work on the establishment of this network is of diverse character as the trunk lines are supposed to be satellite channels using the earth station of satellite links located in the territory of the former military range of Sary-Shagan.

All departments of KazGosINTI were intended to use OC Novell Netware for the local computer network and Unix to run the database servers. The structure of the local computer networks for research information centers were to vary depending on demands. These local area networks in turn were planned to connect to the international Internet, with the work scheduled to be completed in 1996.

Among the networks that were being developed actively in Kazakhstan in the 1990s was SprintNet. At the time besides Almaty, SprintNet nodes were available in four other cities of the republic. In addition to that in 1993 a SOVAMteleport node was opened up in Almaty.

6.9 Malaysia

Sureswaran Ramadass and Azlan Osman

Malaysia began its Internet services in 1987 with Malaysian Institutes of Microelectronics Systems (MIMOS) as the sole provider. MIMOS was first established in 1985 to provide critical infrastructure for the advancement of the local electronics industry. The first Internet service in Malaysia, known as the Rangkaian Komputer Malaysia (RangKoM), connected all the universities in Malaysia to MIMOS to enable researchers from the universities to communicate with each other. The main applications used at that time were email and electronic forums (such as Usenet) and, because the main users were mainly academicians and researchers, the information being exchanged was mostly academically related. The development of RangKoM allowed MIMOS and the universities to create a local talent pool

of individuals experienced with computer networks which, at that time, was a very new subject area in Malaysia.

In 1992, the Joint Advanced Research Integrated Network (JARING) was conceived by MIMOS as part of the 6th Malaysia Plan to provide Internet services to the nation. JARING was connected to many research and academic institutions, including several government and private agencies. Its main objective was to support education, research and commercialization activities in Malaysia. JARING also had a gateway to the international Internet via a 64 Kbps leased line to the United States, introduced in November 1992.

JARING eventually became the first Internet Service Provider for the Malaysian public. JARING was initially opened to public connectivity using dial-up modems. JARING's usage became more popular as a result of the introduction of Gopher and the World Wide Web (WWW). The usage of these two applications eventually resulted in congestion of the JARING backbone, which at that time operated at 64 Kbps. The backbone was eventually upgraded in 1994 to 1.5 Mbps to cope with the dramatic increase in data traffic within JARING. Later that year, JARING was made accessible throughout the nation when nodes were established in sixteen major cities in Malaysia including Damansara, Petaling Jaya, Shah Alam, Bangi, Melaka, Seri Gading, Johor Bahru, Ipoh, Pulau Pinang, Alor Setar, Kuantan, Kota Bahru, Kuala Terengganu, Kuching, Kota Kinabalu, and Kuala Lumpur. This effort enabled even more users to access JARING/Internet services using fixed-line telephones.

More than twenty-seven organizations and government agencies had joined JARING by early 1992, representing more than 200 users. JARING members were made up of students, individuals, and organizations. Individuals and students were able to access the Internet only via dial-up while organizations were able to access it either through dial-up or leased lines. By 1994, JARING use had expanded to 254 organizations with nearly 1,700 individual members.

In 1995, JARING upgraded its links to the nodes in Pulau Pinang and Johor Bahru from 64 Kbps to 2.48 Mbps. By the end of 1995, more than 1,000 dial-up ports were available for users and 40 more nodes were added in 1996 in addition to the 21 existing nodes.

The year 1995 also saw the second link to the international Internet. A dedicated 2.48 Mbps (E1) link was installed in parallel with the existing 1.536 Mbps (T1) link. The E1 link together with the T1 link was able to service the increasing number of users at that time. In 1995, the number of new Internet users within Malaysia was increasing at an average rate of 22% each month. With the 7th Malaysia Plan, the government established the National Information Superstructure utilizing JARING as the infrastructure backbone.

To enable more access to the public, JARING signed a Memorandum of Understanding (MoU) with several companies to form the JARING Access Service Provider (JASP) program that allowed the public to get private support services for accessing the Internet.

JARING also signed a Memorandum of Understanding with Asia Internet Holding (AIH) from Japan to boost its Internet services among local and Asia-Pacific users. The network, known as the JARING A-Bone, allowed faster Internet connections to websites within Asian countries that were also connected to the A-Bone network. By May 1997, JARING offered Internet connectivity to more than 150 countries.

In June 1997, JARING made history with the installation of an international link of 45 Mbps that was also the first of its kind in the region (outside of Japan). The inauguration of this link was also timed in conjunction with INET '97. By the end of 1997, the number of JARING users had increased to more than 100,000 organizations with an estimated 300,000 individual users.

The creation and growth of JARING lay a new path for the telecommunications industry that eventually became a catalyst for many others to follow suit to provide Internet access to the people of Malaysia. The privatization of JARING eventually took place. Today, JARING still stands as one of the main Internet Service Providers in the country despite facing stiff competition.

As the Government of Malaysia saw the potential growth in the telecommunications industry, privatization took center stage and many new companies benefited from the privatization plan, and mobile communication services went on to become more accessible and affordable for all consumers alike. In 1986, the Telecommunications Department of Malaya merged with the Telecommunications Department of Sabah and Sarawak to form the Telecommunications Department of Malaysia to oversee the telecommunications needs of the nation. It was eventually privatized in 1987 and known as Telekom Malaysia Berhad (TM). It went on to be listed on the Malaysian Stock Exchange, Bursa Malaysia, in 1990. Until the year 2000, Telekom Malaysia had the largest market share of fixed lines in the country, totaling 96.7%. Subsequent growth led to a separation of its mobile and fixed services in 2008, allowing the company to focus more on its core businesses of Internet and multimedia, data, and fixedline services [TM 2010].

The Integrated Services Digital Network (ISDN) was introduced by Telekom Malaysia in 1993, followed by the introduction of its Corporate Information Superhighway (COINS), a fiber-optic backbone infrastructure-based IP Network. TM COINS provides fast, scalable, and efficient services including a high-capacity infrastructure able to support multimedia applications with speeds up to 10 Mbps transmitting voice, data, and images. TM Net was later established in 1996 by Telekom Malaysia as part of the Malaysia National Broadband Plan, becoming the second ISP in Malaysia after JARING. It eventually grew to become the largest ISP in the country. To strengthen its dominance as an ISP, the Streamyx broadband Internet service was launched in April 2001 with a speed of 384 Kbps. The introduction of

Streamyx led TM Net to become the most dominant ISP with coverage over the entire nation. Recently, TM Net launched an HSBB (High Speed Broad Band) services at selected locations providing high-speed FTTH and FTTO [Bernama 2009].

Privatization in the mid-nineties saw Telekom Malaysia facing stiff competition in the industry, challenging its dominance over the telecommunications industry. Throughout the decade, many companies sought licenses for various services ranging from fixed line to Internet connection services. While there were many ISPs in Malaysia at the time, Telekom Malaysia's ownership of the nation's last mile connections impeded competition in densely populated areas in major cities that eventually led to TM Net enjoying a virtual monopoly over the broadband market. Present day ISPs that offer DSL broadband services in Malaysia include Giga Broadband, JARING Flite Wired, Maxis Wired, PersiaSYS Ultraband, TIME Business DSL & Broadband and TM Broadband (Streamyx) & UniFi. Wireless broadband services are also offered by several companies including Airzed, AsiaSpace WIMAX, Redtone WIMAX, Axis Broadband, Izzi Broadband, Hotgate Technologies, Inc., JARING Flite Wireless, Packet One and YTL Communications.

6.10 New Zealand

Brian Carpenter

Officially, New Zealand joined the Internet in April 1989, when a 9.6 Kbps modem and a Proteon router at the University of Waikato in Hamilton (120 km south of Auckland) went live with TCP/IP on a cable circuit to the University of Hawaii. The genesis of the connection was two years earlier at a CSNET workshop organised by Lawrence Landweber, but the circuit itself formed part of the PACCOM project sponsored by NASA, so that countries in the Pacific region could collaborate in various scientific projects. Christchurch, New Zealand was (and remains) the jumping-off point for much Earth Sciences research in the Antarctic region. In Hamilton, the man in the technical hot seat was John Houlker; in the USA, there were Torben Nielsen in Hawaii and Milo Medin at NASA. At both ends, of course, numerous others were involved in putting together the necessary financial and technical collaboration-notably John Hine at Victoria University in Wellington, and Tony Villasenor and Jim Hart at NASA.

After establishing the connection across the Pacific Ocean, New Zealand's next challenge was connecting up its other major universities to the University of Waikato. They were situated in Auckland, Wellington and Palmerston North in the North Island, and at Christchurch and Dunedin in the South Island. TCP/IP was already in use internally at some sites. Of course, there was also considerable use of UUCP or BITNET dial-up connections, but at the time, leased lines were still under the control of the Telecom Corporation, split out from the New Zealand Post Office in 1987. Fortunately, Murray Milner, the head of Telecom's Advanced Technology department, was well aware of the potential of the Internet from his time at Carnegie Mellon and Stanford universities. However, both Telecom and the government Department of Scientific and Industrial Research (DSIR) expected that data networking would mainly be based on the X.25 standard, with TCP/IP being treated with considerable suspicion. The various universities knew what was going on in the USA, and champions for the Internet solution appeared, including Nevil Brownlee at the University of

Auckland, John Houlker at Waikato, John Hine and Frank March in Wellington, and Neil James at the University of Otago in Dunedin.

For some time, the universities struggled with IP encapsulation over the DSIR's X.25 network, giving rise to technical difficulties and poor performance. Eventually, changes in Telecom's pricing policy made a switch to dedicated leased lines for TCP/IP attractive. Also, the undersea link to Hawaii was replaced by a 14.4 Kbps satellite link to NASA Ames in California, which was found on balance to be a better and cheaper solution. It did suffer from an outage caused by power supply problems after the October 1989 Loma Prieta earthquake, but was otherwise a noticeable improvement.

Although Telecom officially lost its monopoly during 1989, the company continued to behave like a monopolist for some time, so it was hard for the universities to make progress, even as local rivals to Telecom started up in the major cities. In early 1990, the universities formalized things by setting up a TCP/IP network called Kawaihiko. In the Maori language, *kawai* means a branching structure and *hiko* means electricity. The international Internet gateway, now baptized NZGate, remained at the University of Waikato, and Kawaihiko was a mesh of leased lines running native IP, with no more X.25 in sight. Several universities offered dial-in modem SLIP services, and thus became informal ISPs, some years before the first independent ISPs arose. According to Network Wizards, by 1991 there were more than a thousand Internet connections in New Zealand, not counting the universities, and of course traffic was growing constantly, putting pressure on the expensive national circuits, and even more pressure on the international link. Even today, the cost of international bandwidth remains a primary issue for the New Zealand Internet, with thousands of kilometers of ocean separating the country from Australia, America, and mainland Asia.

Appendix: Internet Status in New Zealand: 1990-1994

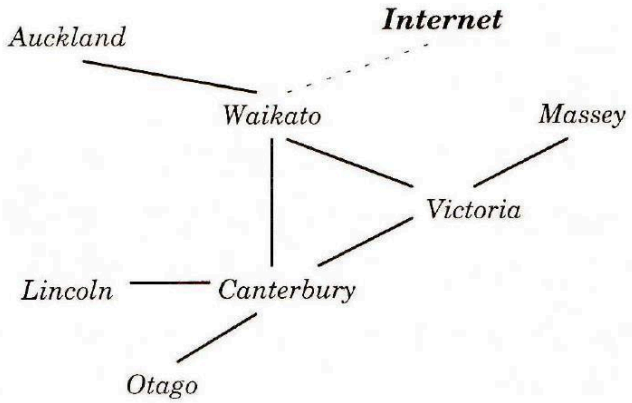

Figure 6-1. The early topology of the Kawaihiko network [Brownlee 1994]

The Internet link was a leased line or satellite link to the USA. The links were leased lines at up to 48 Kbps.

6.11 Russia

Natalia Bulashova, Dmitry Burkov, Alexey Platonov, and Alexey Soldatov

At the end of 1991, the Russian Federation was recognized as the successor state of the USSR in international legal relations. The period 1990-2000 can be characterized as a radical and difficult change in the social and economic situations in the country and as a crucial period in the country's history.

In the first half of the 1990s (1990-94), the limiting factors for the development of telecommunication networks in the country were: (1) the existing general-purpose telephone system infrastructure with its low levels of technology; (2) the limited number of personal computers; (3) the monopoly position of the state telecommunications operator, ROSTELCOM, which owned almost all of the land-based inter-regional telephone channels [Rostelecom 2012]; and (4) restrictions on the delivery of equipment from abroad by the Coordinating Committee for Multilateral Export Controls (COCOM). Please note that these restrictions were canceled after COCOM was shut down in 1994.

Despite all of the complexity in the 1990s, the RELCOM Company has a specific place in Russian Internet history as the company that first started development of the Internet in Russia. From the beginning of the 1990s, the number of personal computers in use was rising driven in part by the rapid development of the Russian market economy and its need to have timely economic, financial, technical and other information, which in turn led to further demand for services provided by computer networks. This resulted in a dynamic extension of RELCOM in territories that were part of the former Soviet Union. In some years during the 1990s, the annual growth of the company exceeded 200-300%. By 1993, the EUnet/RELCOM network was providing a full range of IP services [Sterba 1993].

The period 1992-94 in Russia was also a period of dynamic growth for independent ISP companies. By or during that time, a number of commercial networks were created and in operation: IASnet, Infocom, Interlink, Sovam Teleport, Sprint, FidoNet, GlasNet, and ROSPAK. It must be noted that most of these were highly concentrated in Moscow and had a limited presence in other regions.

Also driving the development of the Russian Internet were Russian science and education networks such as RUNnet, RASnet (EmNet), FREEnet, RSSI, Radio-MSU/RUHEP,
RELARN-IP, RBnet, regional networks in the Urals and Siberia, etc., as well as universities and research centers that formed the initial telecommunications infrastructure and created a market for Internet services in the major cities and regions.

In the period 1996-99, Internet service itself began to shape the telecommunications infrastructure in Russia. During that time, a three-tiered modern infrastructure for the country was put into place in parallel:

- Implementation of large-scale national projects (nationwide network backbone)
- Development and support of regional and inter-regional telecommunications projects

- Smaller telecommunications projects by non-governmental organizations in both the commercial and non-commercial sectors

Among the most important projects on a national scale was the development of a nationwide, primary telecommunications infrastructure based on a fiber-optic backbone installed and managed by ROSTELCOM.

Additional impetus for Internet development in Russia came from emerging new companies such as Transtelecom (1997), Enifcom (1997), Gascom (1992) as they grew to become national service providers with their own nationwide infrastructures.

The period 1994-99 was also marked by the rapid and dynamic development of regional networks which promoted the spread of the Internet throughout the Russian Federation. In most cases, these regional networks built upon ROSTELCOM's inter-regional fiber-optic backbones between Moscow and Novorossiysk, Moscow and Khabarovsk, and Moscow and St.

Petersburg.

In the St. Petersburg region, the Internet piggy-backed on the telecommunications system of the regional energy company, LENENERGO, and over RASCOM, the regional telecommunications railway company, some time later.

In the mid-1990s, the communications system supporting the Russian Internet can be viewed as a multi-ray star topology with Moscow at the center, with links spreading out to other cities in Russia. Gradually, the ends of these rays in various regional cities in turn grew to form regional centers for the outlying areas [Foundation 2012c].

During the period 1996-99, a key role in the areas of science and education was played by a state inter-departmental program called the "Creation of a national computer network for science and higher education" which involved the creation of the Russian Backbone Network (RBnet) to integrate regional and specialized networks such as RUNnet, RASnet, FREEnet, RSSI, Radio-MSU/RUHEP and so on, to provide the science, research, and educational communities with their main telecommunications infrastructure for national and international cooperation and exchange. This inter-departmental state program was run in coordination with the State Project "Universities of Russia" (Direction V), supported by the Ministry of Education, and with the program "33 Regional Universities", supported by the Open Society Institute of the International Soros Foundation. Under the framework of this program, various University Internet Centers were opened and connected to RBnet (through terrestrial links) and RUNnet (with satellite link-ups).

In all, over the ten years 1990-2000, the Russian Internet grew exponentially. By the end on 2000, more than 6.6 million users had access to the Internet [Foundation 2012f].

6.12 Singapore

Bernard Tan Tiong Gie

(1) NUSNET and the Internet

At the time, NUS was upgrading its existing campus computer infrastructure, then based on IBM and VAX mainframes, by introducing a new optical fibre backbone to link up all existing campus networks into a true campus-wide network to be known as NUSNET, which would then be linked to the Internet. The NUS Computer Centre staff under Dr. Thio and his new Assistant Director in charge of networking, Dr. Tommi Chen, worked hard to establish the necessary TCP/IP protocols to communicate with the Internet node at Princeton University. By this time, the backbone of the Internet was NSFNET, established by the National Science Foundation to provide a high-speed TCP/IP backbone to which all the existing networks could link, that is, perform the task of inter-networking by connecting many disparate networks together. ARPAnet itself was shut down in June 1990, having done its job of establishing TCP/IP in 1983 as a viable protocol for inter-networking.

By the time NUSNET went into operation in August 1990, the 64 Kbps Internet link between NUS and Princeton was fully functional, making NUS the home of the first Internet site in Singapore and the region. International networking, though still largely confined to the academic and research community, was experiencing rapid and widespread growth. NUSNET was subsequently launched by the then Senior Minister of State for Education, the late Dr. Tay Eng Soon, as a campus-wide network with full Internet connectivity on 11 April 1991. This meant that we at NUS were now, in addition to email and other simple services offered by BITNET, able to enjoy facilities such as file transfer protocol (FTP) and remote login (Telnet). Other educational establishments in Singapore were subsequently persuaded to link to the Internet via NUS, and to share the costs of the 64 Kbps line.

BITNET and the Internet coexisted at NUS for some time before all the services on BITNET were finally migrated to the Internet. It was wonderful to be able to retrieve files from overseas sites directly through FTP, instead of having to go through the BITNET routine of first requesting and then receiving an index of the archive where a required file was believed to reside, then sending a request for the file itself, receiving the file by email, and finally decoding the file from an ASCII format into a binary format if it was an executable file. The problem of knowing where on the Internet a desired file resided was solved by the Archie sites, which kept archival lists of nearly all the files available on the net. One could login to any of these Archie sites, and if the file one wanted was in the Archie archive, one could find out which sites had that file and then obtain it through remote FTP. The Archie sites were predecessors of the search engines now commonly used on the Web.

Remote login through Telnet meant we could use overseas computers directly, and also use our own NUS computers if we were on leave overseas, so that we could retrieve our email remotely and even run our programs on the NUS computers while out of Singapore. It was also a joy to be able to access the Usenet newsgroups and to participate in Usenet discussions directly, which had not been possible with BITNET. Later on, the Gopher protocol made the direct accessing of resources on remote sites much easier through a menu system which facilitated jumping to other sites. Gopher was, therefore, a direct predecessor of the WorldWide Web and its hypertext links.

(2) Technet

NUS, through Dr. Thio Hoe Tong and Dr. Tommi Chen, then entered into discussions with NSTB, SingTel and the Ministry of Trade and Industry on how to extend the benefits of the Internet to the rest of the research and development community outside of academia. (I had also discussed with Dr. Su Guaning, then Director of the Defence Science Organisation or DSO, the possibility of linking NUS and DSO.) These discussions and the support of Prof. Lim Pin's R&D network in 1992, which became known as Technet. Technet allowed R&D workers in academia, government, and industry to collaborate more effectively with each other, and was another proof that the Internet was a serious and important tool which had vast possibilities beyond the R&D community.

NUS continued its trail-blazing role by establishing the first Gopher server in the region in 1992, and the joint-first World-Wide Web server in the region in 1993. This was www.nus.sg, pioneered by Dr. Chen's successor, Dr. Tan Tin Wee, who is still very active on the Singapore Internet scene. The other joint-first Singapore website was, I believe, set up by another Singapore net pioneer, Jek Kian Jin, who is now in Silicon Valley and was very involved in the Internet start-up scene there.

It was only a matter of time before the Internet would burst its limited boundaries within the R&D community and become available to the public at large in Singapore. SingTel established Singnet, Singapore's first Internet Access Service Provider, in 1994 with the help of Technet. Technet itself was sold to a consortium comprising of Sembawang Media, ST Computer Systems, and Singapore International Media in 1995 and was transformed into Pacific Internet or PacNet, Singapore's second IASP. The rest, as they say, is history.

(3) NUS-cradle of the Internet in Singapore

Reflecting on the surge of excitement over the Internet, the Web, e-commerce, and dot-com startups, it may be appropriate for us to pause and ponder over what might have happened if NUS had not taken its bold steps into BITNET in 1986 and the Internet in 1990. Singapore's prominent position in the Internet world today might not have come about, and our present efforts to establish ourselves as a key e-commerce center would have been delayed by several critical years. It is therefore appropriate for all Internet users today to remember and recognize the vision and foresight of the Vice-Chancellor of NUS, Prof. Lim Pin, as well as the enthusiasm and dedication of Dr. Thio Hoe Tong and his team at the NUS Computer Centre, in enabling NUS to become the cradle of BITNET and the Internet in Singapore and making our country's present position as a leading Internet force in the region and the world a reality today.

6.13 South Korea

Kilnam Chon

(1) Introduction

A TCP/IP network called SDN was in operation since 1982 in South Korea. Many universities and research institutions were members of that network. (Please refer to Chapter 2 for details on the development of SDN.) The international connections used UUCP and CSNET protocols rather than IP, partly due to the United States government restriction on direct IP connections to ARPANET. This restriction was removed in 1986 when NSFNET with TCP/IP was created in the United States. Many countries in Asia as well as Europe started preparations at the time to connect to the USA via IP.

(2) PACCOM Project

In 1989, the University of Hawaii and NASA Ames in California was the focal point of the plan for the PACCOM Project, connecting Australia, USA, Japan, South Korea, and New Zealand, with funding from NASA, the DoE, and NSF in USA as well as funding from each participating country. In Korea, many member organizations of SDN agreed to join the PACCOM Project 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 thus operational.

In the late 1980s, international connections to UUCPNET and CSNET were charged based on the amount of X.25 data packets transferred. As a result, international Internet connections were greatly restricted due to the high costs. However, after the establishment of a leased line connection to NSFNET through the University of Hawaii under PACCOM Project, people could use the international connections with relatively few limitations. Data traffic usage for Internet applications during this time was the highest for FTP, followed by email, Telnet, Archie, and DNS. In August 1992, the main gateway and the operation of HANANET and SDN were transferred from KAIST to the Korea Telecom (KT) Research Center. From that point on, HANANET and the KT Research Center assisted in the development of KORNET, KT's commercial Internet service.

The term SDN was used to designate domestic networks, and the term HANANET was used for networks connected to the global Internet after its launch. With time, the term SDN gradually lost its distinction, and the Academic Network Council (ANC) decided to phase out the use of the name in 1993.

(3) Internet coordination

In the mid-1980s, a series of events occurred that enabled the Internet in Korea to participate as a legitimate partner in the global Internet. The first specifically Korean IP address, 128.134.0.0, was assigned to Korea by the Internet Assigned Numbers Authority (IANA) in July 1986. 'KR' as the country code top level domain to represent South Korea (the Republic of Korea) was put into formal usage that same year. The rules for second- and third-level domains beneath the 'KR' ccTLD designator were also established as well. Five second-level domains were defined, each with two letters each: .AC for academic organizations, .GO for the government, .CO for commercial enterprises, .RE for research organizations, and .OR for

nonprofit organizations. The computers at KAIST and several others sites were registered as domain name servers for the .KR ccTLD (for example, sorak.kaist.ac.kr), thereby putting in place the open infrastructure required to allow the .KR top-level domain to be used both domestically and internationally. KRNIC was set up in 1993 as the agent to handle the administration of the .KR top-level domain name and assignment of IP addresses and AS numbers, among other things.

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

6.14 Sri Lanka

Abhaya Induruwa

The year 1983 was a crucial year for IT development in Sri Lanka. The desire to integrate IT into the socio-economic fabric was expressed at the highest level of the government when His Excellency the President appointed a committee to formulate a national computer policy for Sri Lanka. This was closely followed by policy pronouncements by the University Grants Commission of the Ministry of Higher Education and the University of Moratuwa. All these policy frameworks identified data communications and networking as essential but the University of Moratuwa Computer Policy explicitly stated that "Computer Networking should be the guiding principle in the acquisition of hardware and software systems." Consequently the University of Moratuwa played the Internet evangelist's role and did the pioneering work [Induruwa 1989; Induruwa 1989b; Induruwa 1992] required to establish the Internet in Sri Lanka including conceptualization, design & implementation, demonstration of new technologies and services, popularization and training – all was carried out at the University of Moratuwa. Although much of the preparatory work was done in the early 1990s, and IDD and X.25 based access was used, Sri Lanka did not mark its permanent presence on the Internet until 1995.

(1) Pre-Internet era (1983-1995)

The period from 1983 to 1995 is very important because of the impact made by a number of key decisions and developments that led to the establishment of the academic Internet (LEARN – Lanka Experimental Academic & Research Network) in Sri Lanka. The University Grants Commission held a special meeting of its Inter-University Computing Committee on 28 May 1990 to consider the proposal to set up LEARN [Induruwa 1989] and recommended that "a computer communication network facility must be developed in order to promote interuniversity cooperation." The TCP/IP LEARN [Induruwa 1992] became the first IP WAN in the country, which in turn sparked interests within the commercial sector that

led to the provision of public Internet services. The first commercial ISP – Lanka Internet Services, now defunct – started its operations in 1995.

(2) Early resource development and preparation

In 1985, the Department of Computer Science & Engineering (CSE) was established at the University of Moratuwa to offer a four-year BSc Engineering degree in Computer Science & Engineering. The CSE curriculum included the teaching of data communications and networking to third and fourth-year students. Funds provided by a grant through the Japanese International Cooperation Agency (JICA) were used to establish laboratories including a Data Communication & Networking laboratory and the first Ethernet LAN in a Sri Lankan university, connecting fifty PCs to two VAX 3600 mini computers running Ultrix 32. Staff and students in the CSE department were quick to develop interests in R&D in data communications and networking.

The data communications era in the academic sector in Sri Lanka began in 1985 when a dial-up connection running at 300 bps was successfully used to connect the TRS 80B Xenix multiuser computer at the University of Moratuwa to a similar computer at the University of Colombo and then to remotely log into that computer. Further experimentation was carried out using AX.25 packet radio modems and various modem communication protocols. These early developments allowed staff and students in the CSE department of the University of Moratuwa to steadily develop their knowledge and technical expertise in the areas of data communications and computer networking. This became very useful later when the CSE department undertook the implementation of LEARN and took responsibility for its operation and management.

(3) Early attempts at electronic information delivery

Although the DataNet X.25 packet service offered by Lanka Communication Services Ltd had been available in the country since 1980, the high usage cost limited its use to only organizations such as shipping lines which required a reliable on-line access and data transfer service. Use outside of this was minuscule, apart from a few organizations and individuals using foreign email services such as CompuServe, MCI Mail, or AT&T Mail. Large corporations, IBM, for example, used VNET as their own worldwide internal network.

In 1988, an unsuccessful attempt was made by the Arthur Clarke Centre for Modern Technologies to introduce an email service based on the Mallard mail box. These mail boxes operated with a proprietary communications protocol which was coded in the firmware along with the mailbox ID. This made communicating with anyone outside the “Mallard Club” rather cumbersome [Adams 1992]. As a result, it never became popular.

In 1989, the Sri Lankans studying and living mainly in the USA and the UK who had already been exposed to email and the Internet set up SLNet to fulfill the need for an information channel for Sri Lankans living abroad. SLNet, a moderated mailing list, started with about twenty members and finally grew to about 2000+ members in more than ten countries. The first SLNet relay was located at the University of California, Berkeley. With

interest growing rapidly, SLNet gradually evolved into a sophisticated mail relay system deployed in the USA, UK, and Canada and operated by volunteers for automated information delivery to registered users via email. The main relay was moved to Rensselaer Polytechnic Institute in New York (also serving Northeastern US, Sweden, and BITNET sites) and subrelays were located in Manhattan (for the Eastern US), California (for the Western US, Japan, New Zealand, and the Pacific), Vancouver (for Canada), Keele (for England and Australia), and Edinburgh (for Scotland, Northern England, and Northern Wales). SLNet carried news obtained from wire services including Reuters and Xinhua, transcriptions of radio broadcasts, extracts from news bulletins published by the Sri Lankan Embassies, cricket news, and news posted by members [Firdhous 1996]. From 1991 onwards SLNet operation was funded by LAcNet, a non-profit organization registered in the USA.

In April 1990, as the forerunner to the proposed LEARN [Induruwa 1989], LEARNmail email service was inaugurated by the Department of CSE. LEARNmail functioned by connecting the mail server at the University of Moratuwa, using the UUCP protocol over an IDD connection, to a server in the USA (Fig. 6-2). In 1991, the email volume of about 600 KB per month was exchanged between Sri Lanka and the USA three times a week. With increasing email volume the frequency of exchange was correspondingly increased, reaching twice a day in 1995. During this period, the number of LEARNmail users has risen to about 500. The Department of CSE provided a modem bank for outside organizations to connect to and deposit/collect their email. LAcNet raised funds and met the IDD call costs from 1991 until 1995, when finally LEARN was connected to the global Internet. The .LK domain was registered with IANA InterNIC on 15 June 1990, and the LK Domain Registry was established as an independent non-profit organization and housed in the Department of CSE of the

University of Moratuwa. On 19 August 2010 the Internationalized Domain Names .ලංකා (.LANKA) and .இலங்கை (.ILANGAI), written in Sinhalese and Tamil, respectively, were registered by the LK Domain Registry.

While LEARNmail continued to operate as a stable regular email service, the Department of CSE was experimenting with the packet data services which were becoming available in the country. From 1992, it established a direct connection to the Internet from the LEARN node at Moratuwa using IDD. From 1993, the Moratuwa LEARN node was connecting to the Internet using the Datapac X.25 service of Sri Lanka Telecom. Although costly, this was the first time on-line access to resources on the Internet could be demonstrated in Sri Lanka. This service was made available to select users who could justify their needs and also during various seminars, workshops, and conferences to showcase the usefulness of the Internet and the budding LEARN.

(4) Commercial email providers

The introduction of the LEARNmail email service to the academic sector was soon followed by a number of commercial email providers. They included Information Laboratories (December 1993) and Lanka Internet Services (September 1994). NGO networks such as

Toolnet operated by the ACCMT and the Greennet node operated by LankaNet used FIDO protocols. Foreign email services such as GEISCO, AT&T Mail, MCI Mail, CGNet, and CompuServe continued to operate for those who were using IDD or X.25 to access these services.

(5) Internet era (1995 onwards)

The year 1995 witnessed simultaneous growth in both the academic and commercial sectors, with the latter introducing public Internet access services. The success of LEARNmail and the provision of on-demand access to the Internet via Datapac service became vital in the process of securing funds to establish the first phase of LEARN to connect the University of Colombo and the Open University of Sri Lanka to the LEARN node at the University of Moratuwa. The University Grants Commission provided capital funds to the tune of SLR 3 million. The academic Internet was formed in mid-1995, thus becoming the first IP WAN in Sri Lanka, by connecting together the first three nodes of LEARN using wireless data links operating at 64 Kbps provided by Sri Lanka Telecom. In the same year, Lanka Internet Services Ltd entered the public Internet service sector by connecting to Sprintlink in the USA via a 64 Kbps leased line. This was followed by Sri Lanka Telecom connecting to the JVNC network in the USA using a 64 Kbps leased line. LEARN was connected to the global Internet via an SLT leased line to the JVNC (Fig. 6-3). Funds for this connection were initially provided by the Computer and Information Technology Council (CINTEC) of Sri Lanka, and thereafter, each participating university/institution contributed SLR 300,000 per annum. The National Science Foundation joined LEARN in July 1996, and another fifteen institutions were given access to LEARN via a dial-in server at the University of Moratuwa. To mark the implementation of LEARN and to showcase its capabilities, the NetCon ’95 conference, attended by some 350 people, was held at the University of Moratuwa in January 1995. During the three-day conference, several papers covering various aspects of networks were presented, and on-line access to web-based resources on the Internet was demonstrated.

During the period 1996-98, six more sites were added to LEARN – then called the Lanka Education And Research Network – via 64 Kbps leased lines. The administration and management were streamlined in October 1996 by forming the LEARN Association. Financial matters were handled by the Institute of Computer Technology of the University of Colombo, and the technical matters were handled by the Technical Manager at the University of Moratuwa. An engineer for LEARN was recruited using funds provided by LAcNet.

Several commercial ISPs also started operation in Sri Lanka in the period 1995-96. Lanka Internet Service Ltd was closely followed by Sri Lanka Telecom in 1995. Electroteks Network Services Ltd announced their services in March 1996, connecting via a 64 Kbps satellite link to Canada. Lanka Communication Services Ltd started LankaCom Internet service in July 1996, connecting via a 64 Kbps satellite link to Singapore. The trade and marketing sectors were quick to embrace the Internet and web servers started appearing. Lake House publishing group started publishing the Internet edition of their newspapers in September 1995 followed by the Sunday Times. The Government Information Department

also started publishing their bulletins on-line, and their national website was inaugurated in July 1996.

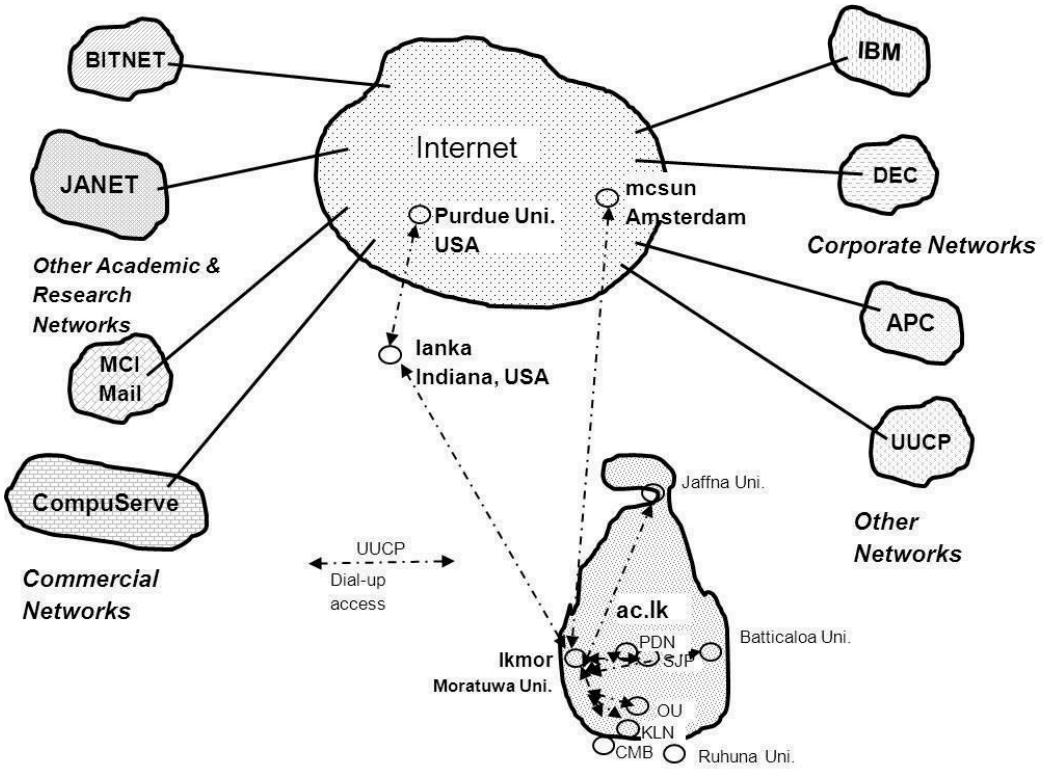

Figure 6-2. LEARNmail Distribution Network (ca. 1990)

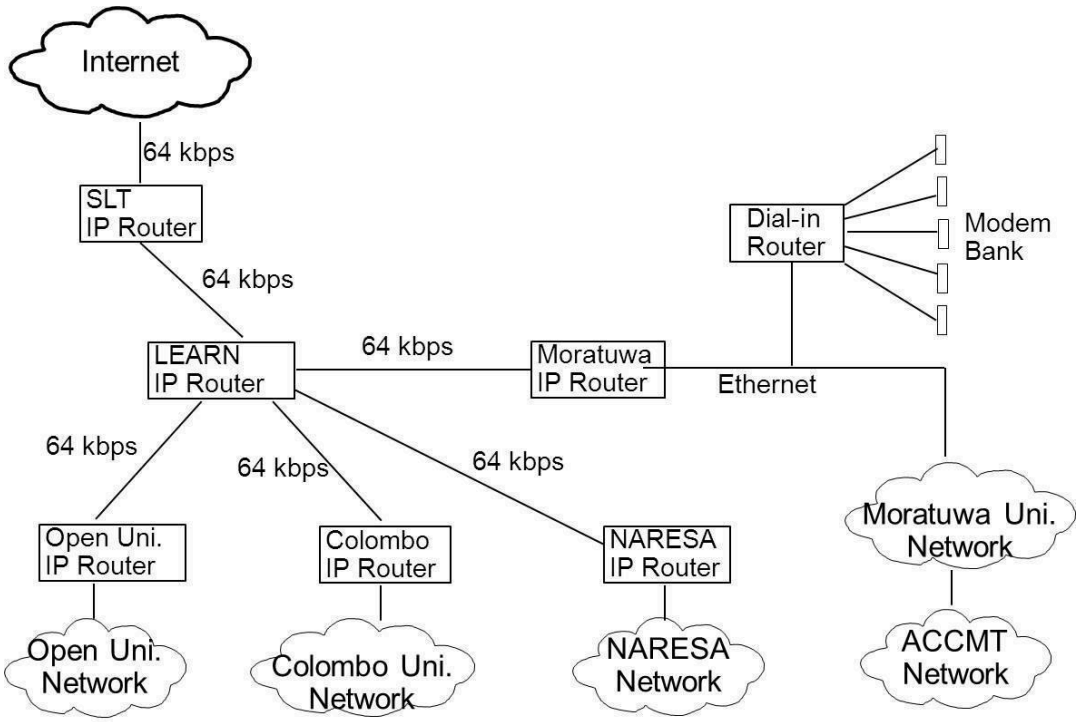

Figure 6-3. LEARN Phase 1 (ca. 1995)

6.15 Taiwan

Vincent Chen

In April 1985, the Taiwan Ministry of Education Computer Center (MOECC) installed IBM host-based Time-Sharing Services terminals on university campuses. This was the earliest prototype of an inter-campus network in Taiwan. Later, VAX-Based InFormation NETwork (IFNET) and CDC-Based UNIversity NETwork (UNINET) projects established host-based computer networks within the major national universities during late 1980s. In August 1987, the first Taiwan BITNET node, *twnmoe10*, connected to SUT (Science University of Japan) by 9.6 Kbps modem and transmitted to the USA. BITNET (Because It's Time NETwork), a worldwide IBM RSCS protocol-based academic network, was the first international academic network in Taiwan. In July 1989, the .TW ccTLD (country-code Top Level Domain) was registered by MOECC with ISI (Information Sciences Institute, University of Southern California). ISI was the predecessor of the IANA, Internet Assigned Numbers Authority.

In July 1990, MOECC initiated the idea for a TCP/IP-based island-wide Taiwan academic network. Thus, the TANet project was born, with a backbone bandwidth of 9.6 Kbps at the initial stage. The Taiwan Ministry of Education (MOE) Science and Technology Office also funded a second-phase Campus Network Development project, focused on an FDDI-based campus backbone and Ethernet-based LAN architecture. In July 1991, the cross-campus infrastructure for TANet was completed among major universities and its backbone was upgraded to T1 (1.544 Mbps). The three-tier network architecture of TANet was implemented using a campus-level, regional-level, and international-level structure. In December 1991, TANet connected to the Princeton University JvNCnet (John Von Neumann Computer Network, an Internet hub located on the US east coast), based on an Internet TCP/IP protocol over a 64 Kbps leased line. Thus, 3 December 1991 is the date that marks Taiwan's first connection to the Internet.

In July 1992, SEEDnet started the earliest trial project for enterprise Internet connection. Due to the restrictions of the Telecommunication Law, SEEDnet was forced to connect indirectly to the Internet, connecting via III (The Institute of Information Industry). In December 1992, TANet upgraded its international Internet bandwidth from 64 Kbps to 256 Kbps connecting to the USA JvNCnet.

In January 1994, HiNet was formally established and opened for trial testing. HiNet also launched the first Taiwanese international commercial information highway to the US. At the same time, HiNet also connected to TANet through a 64 Kbps link. This was the first peering link in Taiwan. The TWNIC trial plan was born for commercial Internet services, including domain name registration and IP address allocations. The trial plan's committee was convened by the Director of MOECC, and its members were drawn from the government, enterprise, and non-profit organizations. In March 1994, the TANet management committee decided to extend the TANet infrastructure to senior high schools, junior high schools, and elementary schools to promote information education. TANet also decided to help create Education Network Centers at each county and city level. In October 1994, TANet

upgraded its international Internet bandwidth from 256 Kbps to 512 Kbps connecting to USA JvNCnet.

In April 1995, HiNet formally launched its commercial operations. Its number of trial accounts reached about 3,558 and, at the same time, also upgraded its international link bandwidth to the T1 level. In July 1995, MOECC ceased its international connection to BITNET and BITNET passed into the history of Taiwan academic networks. In October 1995, TANet upgraded its international Internet bandwidth from 512 Kbps to 1544 Kbps (T1) connecting to USA JvNCnet.

In January 1996, due to its doubts raised by the threats of the president of the United States, the Ministry of Education announced the implementation of a draft regulation for BBS and Web sites on campus. This announcement was strongly protested by the on-campus Internet community. The Legislative Yuan passed "three laws of telecommunications" – the new telecommunications law, the DGT Organizational Law, and the ChungHwa Telecom Organization law. These laws opened up a new era in the telecommunications industry in Taiwan. In May 1996, TANet upgraded its international Internet bandwidth from one T1 to two T1 links and changed its connecting US east coast partner JvNCnet to US west coast partner GLOBAL-ONE.

In January 1997, TWNIC started studying the possibility of implementing interconnection rules for Internet exchange in Taiwan. It also suggested the establishment of TWNIC CIX, to be operated by a CIX task force or outsourced within one or two years. In November 1997, TWIX started its peering services for ISP operators. TWIX provided T1 and T3 options for peering connections.

In January 1998, TWNIC started charging fees for COM.TW, ORG.TW AND NET.TW domain name registrations. The fees were NT$500 for initial setup service for the first year and NT$1000 for management services annually. In March 1998, the number of Taiwan public Internet users broke the two million person mark. In November 1998, TANet upgraded its international link to T3 (45 Mbps) and adopted a fee-sharing, bandwidth-sharing agreement between MOECC, ASCC, and NCHC. In December 1998, in line with the government's plans to extend domestic demand, TANet members decided to adopt CHT's ADSL solutions for school internet connections based on the resolution of the Alishan meeting. This resolution impacted the ADSL broadband solutions in Taiwan significantly.

In May 1999, DGT attended the 2nd ICANN GAC (Government Advisory Committee) in Berlin with observer status. This official participation was urged by NCHC, MOECC, and related Internet experts after their attendance at the 1st ICANN and its GAC meeting in Singapore in March 1999. In June 1999, the NBEN (National Broadband Experimental Network) was established by a task force of the National Telecommunications Project. It opened up the window for Inetnet2 connection with US NGN (Next Generation Network) communities. In October 1999, to meet local Internet requirements, an Internationalized Domain Name pilot system was launched as part of a project lead by the

Academia Sinica Computing Center (ASCC). This iDNS project paved the way for TWNIC's adherence to global IDN (Internationalized Domain Name) standard procedures.

The rapid development of Taiwan's Internet in the 1990s laid a solid foundation for Taiwan's broadband and mobile networks in the early 2000s. However, the development of the Internet in Taiwan still needs more active planning and initiative in order to cope with the increasingly complicated, important, global trends of economic development.

6.16 Thailand

Kanchana Kanchanasut

In 1986, I used the ITU-T X.28 protocol which is a dial-up X.25 protocol to log in remotely to *munnari* (University of Melbourne) in Australia and started working with Robert Elz to develop further our connectivity. My colleague, Tomonori Kimura, at the Asian Institute of Technology (AIT) also contacted his colleagues in Japan at the same time. We ran UUCP on X.25 with Melbourne and the University of Tokyo.

In late 1987, we acquired our first SUN Workstation and so were able to test our UUCP connections with Australia (Robert Elz) and later on with Rick Adam at UUCPNET (USA), INRIA (France) and also the University of Tokyo (Japan). We experimented with TCP/IP inside AIT using Sun Workstations and Fujitsu Unix PCs. A stable UUCP connection to the outside world was achieved between AIT and UUCPNET (USA) due to the quality of the international long distance phone line.

July 1988 marked the birth of the Thai domestic network called the Thai Computer Science Network, with the support from the Australian International Development Agency which provided us with their software called ACSNET (SUNIII) to connect Prince of Songkla Univerisity (PSU), Chulalongkorn University (CU), Thammasat University (TURangsit) and AIT together. All sites had to use Unix, which was very unusual at that time in Thailand. Chiangmai University joined this networking community later on. AIT and PSU acted as gateways to the Australian Academic Research and Education Network (AARNet) using ACSNET through which the TCSNET community could communicate with the global TCP/IP network or the Internet. AIT was the gateway to ACSNET as well as to UUCPNET with UUCP at the same time. With the adoption of ACSNET, the country code TLD 'TH' and a Class C IP address were applied for and awarded to AIT in June 1988. The operation of the TCSNET gateway at AIT was under the care of Pensri Charoenchai. Email addresses were provided to academic colleagues both within and outside AIT with dial-up accounts to AIT.

A workshop was organized by AIT in December 1991 attended by all Internet pioneers in Thailand where it was agreed to push for a leased line from Chulalongkorn University to UUCPNET using TCP/IP and a set of rules using 'TH' as the ccTLD were drafted at that time. In May 1992, Thammasat University (main campus) became another gateway to ACSNET.

In 1992, Chulalongkorn University acquired a leased-line connection to UUCPNET in the USA via TCP/IP. The first PING to the USA from Thailand took place on 16 July 1992

at 9600 bps, which was later upgraded to 64 Kbps in 1993. Members of TCSNET gradually migrated to TCP/IP and connected themselves to the gateway at Chulalongkorn University to form a network of Thai universities called THAINET. Subsequently the 'TH' ccTLD registry was moved to Chulalongkorn University.

During 1986-92, there was another project ongoing under the leadership of the National Electronics and Computer Technology Center (NECTEC) to connect local universities via X.25 (Chulalongkorn University, Kasetsart University, AIT, King Mongkut Institute of Technology at Lat Krabang, and King Mongkut Institute of Technology at Thonburi). In 1992, the project adopted TCP/IP over X.25 and achieved connectivity beyond what were originally planned. Within the same year, NECTEC launched a Thai Social, Academic and Research Network (ThaiSarn) as a country-wide Internet project with a second link from Thailand to UUCPNET in 1993 at 64 Kbps. All members of TCSNET were included in ThaiSarh and achieved reliable international connectivity through gateways at Chulalongkorn University and NECTEC.

By 1995, with the success of these two research and education networks, the Internet in Thailand started to receive much attention and demand from the public at large. The Communications Authority of Thailand (currently CAT Telecom Plc.) was convinced to issue operating licenses to two commercial ISPs which started their operations in February (Internet Thailand) and June (KSC), respectively.

The research and education network in Thailand soon expanded with funding support from the then Ministry of University Affairs when a new research and education network serving Thai Universities called the University Network (UniNet), designed by Dr. Yunyong Tengamnuay of Chulalongkorn University, was launched in 1996 with an aggregate 4 Mbps link to the global Internet. ThaiSarn and UNINET jointly formed ThaiREN (Thai Research and Education Network) in 2005.

The domain name registration task was jointly provided by Chulalongkorn University and AIT until 1999 when the non-profit THNIC organization was formed.

6.17 Turkey

Bunyamin Atici

The starting point of Internet use in Turkey was the establishment of the *Turkish Network* of *Universities* and *Research* Institutes (TUVAKA) leading by ULAKNET in 1986. The first Wide Area Network (WAN) connections were established between BITNET (Because It's Time NETwork) and EARN (European Academic and Research Network) through the Middle East Technical University (METU-ODTU) in 1987.

In September 1992, the first Internet connection in Turkey was provided through an X.25 circuit that was established between METU and Holland. With the TR-NET project initiated through the cooperation of METU and the Scientific and Technological Research Council of *Turkey (*TUBITAK) on 12 April 1993, a 64 Kbps Internet connection was established between METU and NSFNET (National Science Foundation Network) using the

TCP/IP protocol. From 1993 to 1996, leading universities and several government institutions connected to the Internet via this 64 Kbps system of METU.

In 1995, the speed of the Internet connection was increased to 64 Kbps. In October 1996, ULAKNET-NSFNET (from the USA) connection speed was increased to 512 Kbps over METU. In the month of August 1998, university entrance examination results were, for the first time, announced over the Internet through ULAKNET in Turkey. In total, 1.5 million people accessed the examination results in two days over ULAKNET servers.

By the end of 1999, ULAKNET provided Internet services to eighty universities and research centers from 114 points. The connections from Ankara, Turkey to the USA were provided at 10 Mbps from three locations. Since 1996, Internet use has been available for companies and homes. In 1996, the TURNET Project that provided Internet connections from Turkish Telecom to commercial institutions and Internet Service Providers (ISP) was approved. The number of ISP companies that commercially benefited from three lines ¬ two from Istanbul (2 Mbps and 512 Kbps) and one from Ankara (2 Mbps) – had increased to eighty by October 1997. During that year, ISPs started to sell the Internet services to third parties at the price they decided. Starting in the middle of 1997, at around the same time as other countries, Internet service became popular in Turkey, too. Also, since the end of 1996, many daily newspapers and journals started to be published online. In addition, by the end of 1997, stores started providing online shopping opportunities for their customers. During those days, despite the slow Internet connections, online radio and TV broadcasting became popular. At the end of 1997, the number of companies that used the Internet was about 10,000, the number of computers was about 30,000, and the number of people who used the Internet reached about 250,000.

6.18 Vietnam

Le Thuy Cam

The Hanoi Institute of Information Technology, part of the National Center of Natural Sciences, cooperating with a German university, undertook efforts in 1991 to launch the Internet with the objective of exchanging emails within Vietnam, but it was not until late 1992 that the first international connection was established.

Assistance in 1993 from the Australian telecommunications company, Telstra, allowed the service to be automated using UUCP protocols and, in 1994, with the aid of a grant from the Australian Department of Employment Education and Training, email service was extended to include Hanoi University. This network soon expanded to become the first internationallyinterconnected Vietnamese network, VARENet (Vietnam Academic Research and Education Network). Another network, NetNam, was launched in 1994 under the auspices of the Hanoi Institute for Information Technology with aid from the Canadian International Development Research Centre and it's Pan Asia Networking project. By 1996, NetNam had attracted several hundred users, including some 60 NGOs operating in Vietnam at the time.

By early 1996, Vietnam was position to establish a full-time, unlimited connection to the global Internet. The first ISP and licensed Internet Access Provider (IAP) was VDC, a stateowned subsidiary of Vietnam Post and Telecommunication Group (VNPT). After the packetswitched network, VIETPAC, was built and put into service in 1992, VNPT authorized VDC as an investor to build the packet-switched network VIETPAC. The VIETPAC network was a public data packet-switched network the DNIC (Data Network Identification Code) 4520.

In 1996, VDC launched online email services using an X.400 protocol to connect a number of X.25 packet switches under the domain name 'vnd.vn'. VDC continues to be one of the top Internet connection service providers (IXP) in Vietnam.

6.19 Africa

Pierre Dandjinou

On 12 November 1991, an IP "ping" packet was sent from Rhodes University's computing center in Grahamstown, South Africa to the home of Randy Bush in Portland, Oregon. This is the earliest known IP connection between sub-Saharan Africa and the rest of the world, and thus marked the start of Internet connectivity in this continent. Many other African countries followed suit along their different paths, however, at the beginning of the 1990s, African countries were relying upon X.25 IPSS and 2400 baud modem UUCP links for international and Internetwork computer communications. Twenty years down the road, a lot has changed, with the Internet now becoming part of daily life on the continent.

Africa started active participation in one-day Developing Country Workshops in 1991 and 1992. Six countries in Africa participated in 1991: Cameroon, Ghana, Nigeria, Tanzania, Zambia, and Zimbabwe along with seven more countries from Asia and Latin America [Abba 2012]. Fifteen countries from Africa participated in 1992. The workshop participation was funded by the United Nations Development Programme and the Internet Society among others and was organized by CNR-CNUCE in Italy. Later, many more Africans participated in the week-long Developing Country Workshops during INET in the 1990s, and many of them became the Internet pioneers in Africa.

Development agencies were somewhat instrumental to the early interest in Internetworking activities in Africa in the 1990s. Thus, USAID, as a part of its PSGE project, sought to establish electronic communication between the United States and African collaborators on the one hand to coordinate with existing email providers such as MANGONET, RIONET and CGNET, and later to connect the more than 100 African institutions which work with PSGE to the Internet [USAID 2012].

The Leland Initiative, also called the Africa GII Gateway Project, was a USAID five-year $15 million project to connect up to twenty African countries to the Internet was then launched, with an additional goal of creating an Internet service provider industry.

In the aftermath of RIO conference of 1994, the United Nations Development Programme (UNDP) launched its Sustainable Development Networking Programme (SDNP)

to assist with development of Internet and Information Services with emphasis on sustainable development. The initiative kick-started networking in twelve pilot countries in 1992. This evolved later on into assistance services aimed at establishing connectivity to national networks and the Internet, content provision, and aggregation, and user training in forty developing nations and thirty-six small island developing states.

Based in Pisa, RINAF, the Regional Informatics Networks for Africa, was also initiated in 1992 as a framework for UNESCO's support for African co-operation to promote academic and public sector computer networking. RINAF started with support from Italy, and complementary assistance from the Netherlands, the Republic of Korea, and UNESCO's Regular Programme.

RIO (Réseau intertropical d'ordinateurs) was established as an organization to provide electronic connectivity in Francophone Africa under the French government funded Institut de Recherche pour le Développement.

With the organization of the African Regional Symposium on Telematics for Development on 3-7 April 1995 by the United Nations Economic Commission for Africa (UNECA), the ITU and IDRC, the stage was set for a series of electronic networking and Internet for development forums which culminated in the design of the Africa Information Society Initiative spearheaded by the UNECA.

A host of Internet-related projects was initiated in the mid-1990s by NGOs and national agencies as well, to foster networking activities in connection with the local development, with telecenters and cybercafés as central pieces. These efforts paved the way for the transformation of the Internet landscape which occurred later on with the formation of Internet-related professional associations which sought to deepen capacity building and ensure African participation in global Internet governance, the awakening of a local private sector, the initiation of massive communication infrastructures to cope with the changing ecosystem, and the increased awareness of content development in Africa.

Interestingly, in 1998, Africa organized the first ever Internet governance conference in Cotonou, Benin [Dandjinou 1998]. This gathering triggered the dynamics that have partly outlined the Africa Internet ecosystem as we know it today. The development has been laborious along a steep path, with many different players – from individuals to institutions – having left their footprints.

6.20 Europe

Brian Carpenter

The years 1988 through 1992 were perhaps the most interesting period in the history of the European Internet, so a snapshot in 1990 is just one scene in an action movie. It should not be forgotten that this period covered the fall of Communism in Europe, the end of the USSR, the reunification of Germany, and the disintegration of Yugoslavia. These tremendous events were only one factor, of course; another major influence was the progressive liberalization of telecommunications in Europe.

In 1988, the major concern in most organizations was to get away from proprietary solutions, at the same time as extending the network out from the traditional computer center to the personal computers that were appearing on every desktop. In the academic world, networking was a mixture of DECNET, UUCP, EARN/BITNET, and of course increasing use of TCP/IP for Unix-based workstations and servers. Almost everywhere, however, the official policy was migration to OSI protocols. By 1992, the OSI dream was crumbling (except in the minds of some government and European Commission officials), the Internet in Europe had taken shape, and – thanks to liberalization – link speeds had increased from kilobits to megabits. National research and academic networks (NRENs) were consolidating in Western Europe and emerging in the former communist countries of Eastern Europe. Although not yet widely known outside the high energy physics community, the killer application-the World-Wide Webhad been invented at CERN. However, it is often forgotten that the Internet grew exponentially in Europe during those years, even without the Web.

A significant event in 1989 was the creation of RIPE [RIPE 2012], an organization started by TCP/IP users to coordinate things like naming and numbering. RARE [TERENA 2012] was the organization of the European NRENs, officially dedicated entirely to OSI deployment. At the RARE conference in 1989, Brian Carpenter dared to present a paper entitled “Is OSI too late?” By January 1990, meeting in Vienna, RARE agreed to recognize TCP/IP as an alternative to OSI and started a formal relationship with RIPE. Later that year, at the first RARE/EARN Joint European Networking Conference in Killarney, Ireland, a pragmatist’s “birds of a feather” session was the initial step towards what became the EBONE, the first real European IP backbone network, which started carrying packets in 1992.

Another significant event of 1989 was the first megabit TCP/IP link between Europe and the USA. In 1987, IBM created their European Academic Supercomputer Initiative, and by 1989 the associated EASInet network was set up, linking various academic supercomputer sites in Europe. IBM agreed to fund a T1 (1.5 Mbps) link from CERN to Cornell University, which connected EASInet to the NSFNET. Thus, Europe acquired its first high-speed link to the Internet. Later, as IBM’s generous funding was phased out, this link became part of the EBONE infrastructure. Later still, as OSI faded even from official government plans, EBONE was privatized and the NRENs could avail themselves of a mixture of commercial connectivity or of international connectivity provided by DANTE [DANTE 2012], an international operational unit set up in 1993 in collaboration with TERENA [TERENA 2012], the successor of both RARE and EARN. At the same time, locations such as Amsterdam, Stockholm and London were becoming major hubs for Internet connectivity, and commercial providers such as Pipex in the UK were appearing.

In the middle of this turbulent period, the RIPE host count for 2 October 1990 showed 31,724 hosts in nineteen countries (see document RIPE-020). The worldwide host count was then a little over 300,000, so Europe already represented about 10% of the Internet. The RIPE host count passed 400,000 about the end of 1992, when the worldwide count was about 2 million. Thus, Europe then accounted for 20% of the size of the Internet, roughly the same as today. The growth rate in network capacity was equally startling. Considering only the numbers for CERN, at that time the undoubted European hub for scientific data

networking, the total capacity at the end of 1990 was above 10 Mbps, more than ten times what it was in 1988. Not only had the size of the European Internet grown dramatically, but so had its geographical spread, beyond the countries of Western and Nordic Europe, to include first Croatia and Slovenia, and subsequently the Baltic countries, most of Eastern Europe, and several of the former states of the USSR. Today, TERENA itself has some thirty-nine national members, each representing an NREN. Of course, unlike 1990, the majority of the estimated 500 million European Internet users in 2012 are ordinary citizens, not academics.

6.21 Latin America and the Caribbean

Michael Stanton

In Latin America and the Caribbean, one can observe the same general pattern of development of academic networking services as in many other parts of the world, beginning with email networks, such as BITNET and UUCP, installed from 1986 onwards, and migrating to IP networks beginning in 1989. Without any doubt, the main inspiration for these activities was a result of the advances in the USA, which became very visible after the launch of the NSFNET in 1985.

In what follows, we divide the region into two parts: (1) the Spanish and Portuguese speaking nations on the region's continental mainland, and (2) the island nations in the Caribbean, and the non-Spanish or non-Portuguese speaking nations on the mainland.

Region 1 includes 17 states: *MX-Mexico, AR-Argentina, CL-Chile, BR-Brazil, NINicaragua, UY-Uruguay, PY-Paraguay, VE-Venezuela, CR-Costa Rica, CO-Colombia, ECEcuador, PE-Peru, BO-Bolivia, PA-Panama, GT-Guatemala, SV-El Salvador, HN-Honduras.*

Table 6-1 Introduction of international connectivity for email (BITNET/UUCP) and IP networks in Region 1

	MX	AR	CL	BR	NI	UY	PY	VE	CR	CO	EC	PE	BO	PA	GT	SV	HN
Email	86	86	86	88	88	88	89	90	90	90	91	91	91	92	92	94	94
IP	89	90	92	91	94	94	95	92	93	94	92	94	95	94	95	96	95

Region 2 includes the mainland states of Belize, Guyana, and Surinam, as well as the very many island nations in the region, as well as some European territories. Of these, we shall be concerned only with those that achieved network connectivity by the mid-1990s.

Table 6-2 Introduction of international connectivity for email (BITNET/UUCP) and IP networks in Region 2

	JM	DO	BS	AG	TT	BB	DM	BZ	GD	SR	LC
Email	*	*			*	*		*	*	*	*
IP	94	95	95	95	95	96	96				

JM-Jamaica. DO-Dominican Republic, BS-Bahamas, AG-Antigua & Barbuda, TT-Trinidad & Tobago, BB-Barbados, DM-

Dominica, BZ-Belize, GD-Grenada, SR-Surinam, LC-Santa Lucia
** = member of the Caribbean Universities Network (CU-Net)* [Organization 2012]

All of the email networks in Region 1 were directly connected to the USA, except for a BITNET connection between Argentina and Chile [Baeza-Yates 1993]. The earliest email networks were either dial-up UUCP or usually permanently connected BITNET networks, and first began in 1986 in Mexico, Argentina, and Chile. By 1990, coverage had spread to Brazil, Paraguay, Columbia, Uruguay and Venezuela in South America, and to Costa Rica and Nicaragua in Central America. In Region 2, UUCP connections were generally made through the Caribbean Universities Network, based in Puerto Rico [Organization 2012].

The first IP connection from Region 1, again to the USA, was made from Mexico in 1989. With the establishment of IP connectivity, email networks tended to disappear. The dates of all IP connections to the NSFNET until 1994 are registered in [Internet 2012], but seem to be in error in the cases of Brazil and Chile, which were recorded by those involved, respectively, as
1991 [Stanton 1993] and 1992 [Baeza-Yates 1993]. Those after the end of NSFNET in 1995 have been obtained from other sources, and are often provided by commercial ISPs. Very many of the IP connections in Region 1 and Region 2 were established through the "HemisphereWide Inter-University Scientific and Technological Information Network" (RedHUCyT, an acronym in Spanish), an initiative of the Organization of American States [Hahn 1995; Organization 2012]. With a couple of exceptions in Central America, all regional links were to the US, and usually used satellite services.

The spread of commercial or commodity Internet services in the later part of the 1990s had a significant impact on the development of the research networks of Latin America, in some cases simplifying their international connectivity, and in others leading to the disappearance of most of them by the end of the 1990s, either because they were not economically more attractive than offerings of the new ISPs, or because the academic networks themselves began offering commodity services. By the year 2000, only eight functioning research networks remained in Latin America, either through the financial support of government (in Brazil, Costa Rica, Cuba, Uruguay and Venezuela) or of private industry (in Mexico), or by having built up a sustainable membership organization to maintain the networking infrastructure and its operations (in Argentina and Chile).

It was only in 2004 that non-US-centric research networking came to LA&C. That year saw the creation of the RedClara regional network, linking together most of the countries in Region 1, and providing separate shared interregional connections to the USA and Europe [RedCLARA 2012; Stover 2010]. In 2012, C@ribNET for the first time provided a regional network for Region 2 [Caribbean 2012].

6.22 North America

Steve Goldstein

The ten or so years surrounding 1990 in North America witnessed the emergence of most of the features in use on today's Internet. Key among the developments in this period was the abandonment of several networking protocols (e.g., BITNET, DECNET, ISO/OSI, etc.) and the convergence to TCP/IP ("IP," or "Internet Protocol") as the predominant networking protocol. The abandonment of protocols in use for many years in favor of the conversion to TCP/IP was often a controversial matter in the US, as in other parts of the world, especially Europe, but eventually pragmatism prevailed.

TCP/IP operated over network backbones that grew from 56 Kbps over X.25 (e.g., ARPANET and 1986 NSFNET backbone), to T1 (1.55 Mbps, e.g., 1989 NSFNET backbone), to T3 (45 Mbps, e.g., 1991 NSFNET Backbone Service over a network operated by the newly formed ANS). While the NSFNET served most of the higher education and research community in the US, NASA and the Department of Energy (DoE) implemented their own networks to serve their research communities.

Canada commissioned its academic network, CA*Net, in 1989 as a 64 Kbps thin-line backbone connecting its population centers close to the Canada-US border. CA*Net connected to the NSFNET at three locations. CA*Net's portfolio was later broadened to include Canadian industry as it was transformed into the Canadian Network for Advanced Research, Industry and Education (CANARIE), a world-class network.

Mexico's Internet, Red Académica de Mexico (Mexican Academic Network), began with a connection from the astronomical observatory of the Autonomous University of Mexico (UNAM) to the National Center for Atmospheric Research in Colorado in the late 1980s.

As the network bandwidths increased, new switches (routers) were developed, and the Border Gateway [routing] Protocol (BGP) was developed and implemented to improve the routing architecture, as was Classless Interdomain Routing (CIDR) both to manage the everincreasing size of the routing tables and to squeeze more usable addresses out of the dwindling IPv4 address space. (See, for example, "NSFNET: A Partnership for High-Speed Networking, Final Report 1987-1995," Merit Network, Inc.)

By 1994, the meteoric rise of commercial networking eclipsed the much slower growing academic and government networks and laid the groundwork for entirely new forms of commerce.

For example, below are circa 1998 depictions of US Federal Network (i.e., NSFNET, ESnet, NASA Science Network) backbones and selected commercial network backbones in the US, respectively (from the archives of Steve Goldstein):

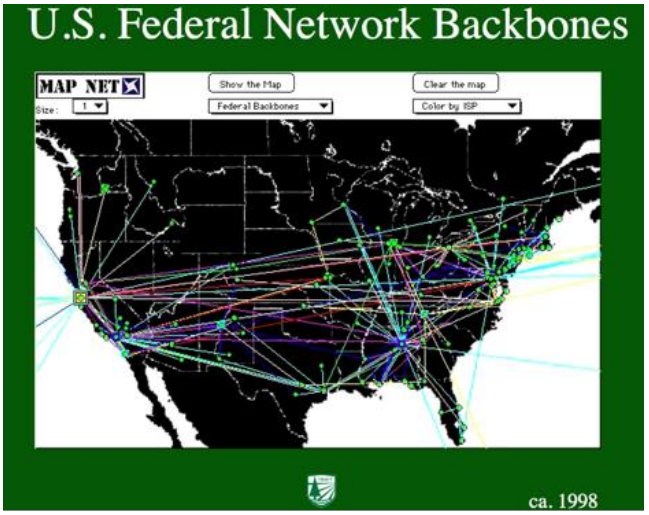

Figure 6-4. US Federal Network Backbones (ca. 1998)

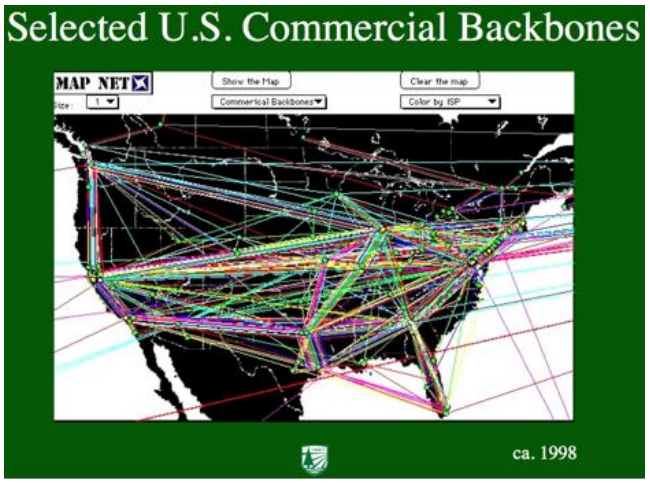

Figure 6-5. Selected US Commercial Backbones (ca. 1998)

When the two are overlaid, there is hardly any visual difference from the commercial backbones alone:

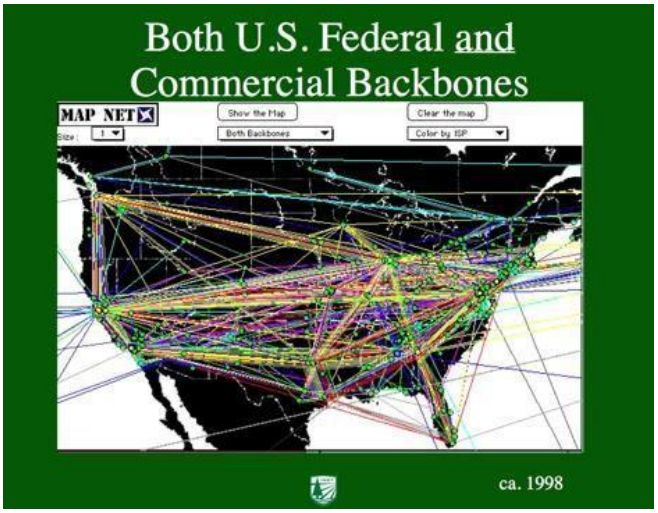

Figure 6-6. Both US Federal and Commercial Backbones (ca. 1998)

As networks proliferated, interconnection facilities, or, more formally, Internet Exchanges (*IXes) were established to promote widespread connectivity and efficient use of pre-fiber optic network resources.

International connections to US networks by satellite and undersea cables proliferated, first among academic networks, and later among commercial networks, though 45 Mbps international connections to *IXes awaited the establishment of the STAR TAP in 1997 (to support the G7's 1995 Global Interoperability of Broadband Networking (GIBN) Initiative). "Only three countries were connected by the NSFNET Backbone Service when the T1 network came online in 1998: the US, France and Canada. Ten to twelve countries were added each year until 1993; in 1994, the last full year of the NSFNET project, twenty-one new countries were added. At the end of the project, ninety-three countries had been announced to the NSFNET backbone service." [NSFNET 1996] In 1991, NSF established the International Connections Manager (ICM) project to assist academic networks of other countries in connecting to the NSFNET. By the close of the ICM project in 1996, some twenty-five countries had been added (note that some of the entries contain multiple countries):

Of particular interest to Asian networking, the Pacific Communications Network (PACCOM) was organized by NASA in the late 1980s, and it connected Australia, Japan, Korea, and New Zealand. In 1991, NASA, the Department of Energy (DoE), and NSF co-funded the US portion of PACCOM with an award processed through NSF. Throughout the period, NASA and DoE also funded international links to support their science missions.

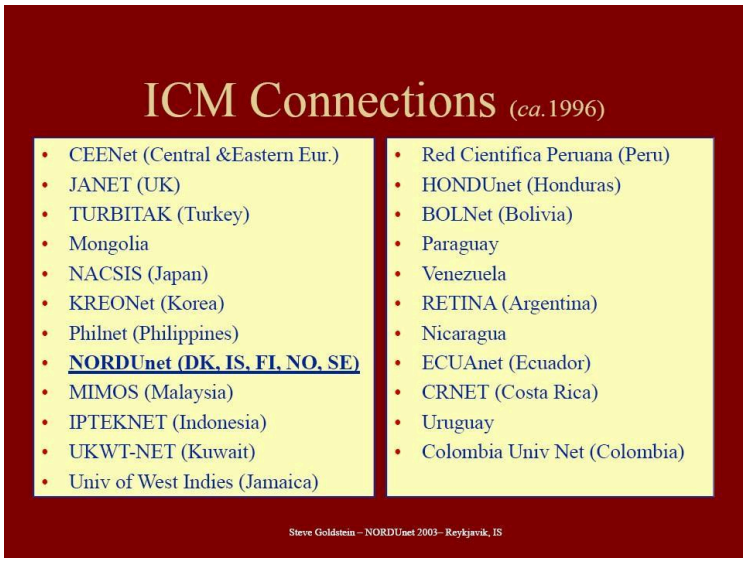

Figure 6-7. NSF International Connection Managers (ca. 1996) [Goldstein 2003]

The rapid growth of network capacities was driven by user demand, and, in turn, user demand was enhanced by a progression of user-friendly tools for search, file transfer, and hypertext linking, leading up to today's browsers and search engines. Access to the World Wide Web, birthed in 1991 at CERN in Geneva, was enabled for the common user by the

dawn of the browser with a graphical user interface, Mosaic, at the National Center for Supercomputer Applications in 1993. Mosaic was the father of Netscape, Internet Explorer, the Mozilla family of browsers, and others to follow. And even before the appearance of the browsers, search engines, starting with Archie in Canada in 1990, were refined to set the stage for the Googles and Bings of today.

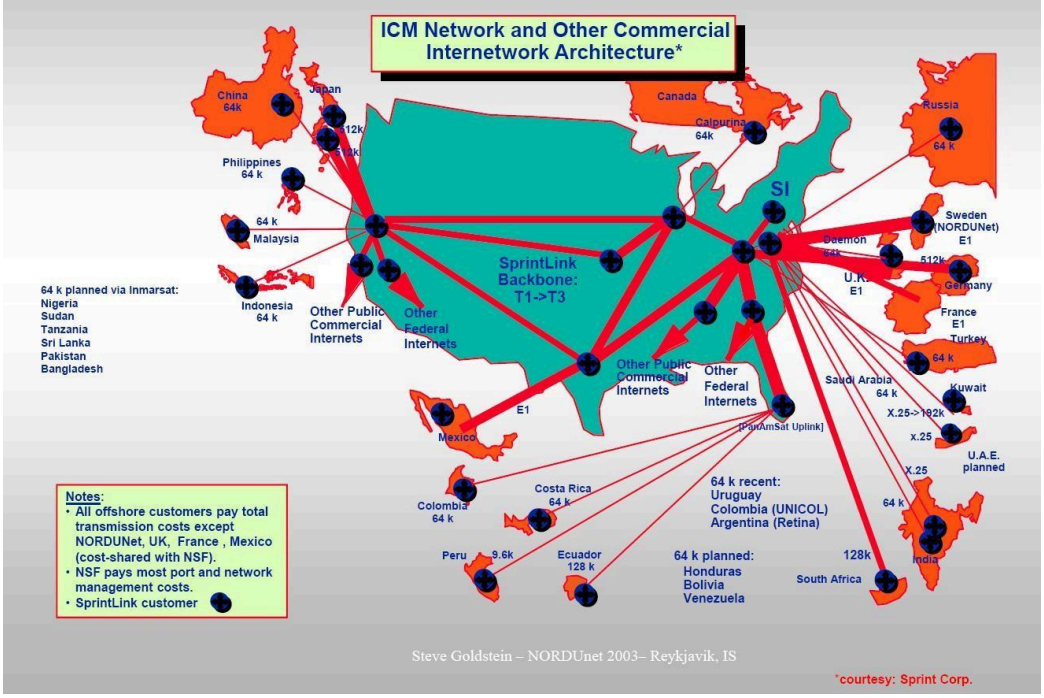

Figure 6-8. NSFNET's International Connections (ca. 1994) [Goldstein 2003]

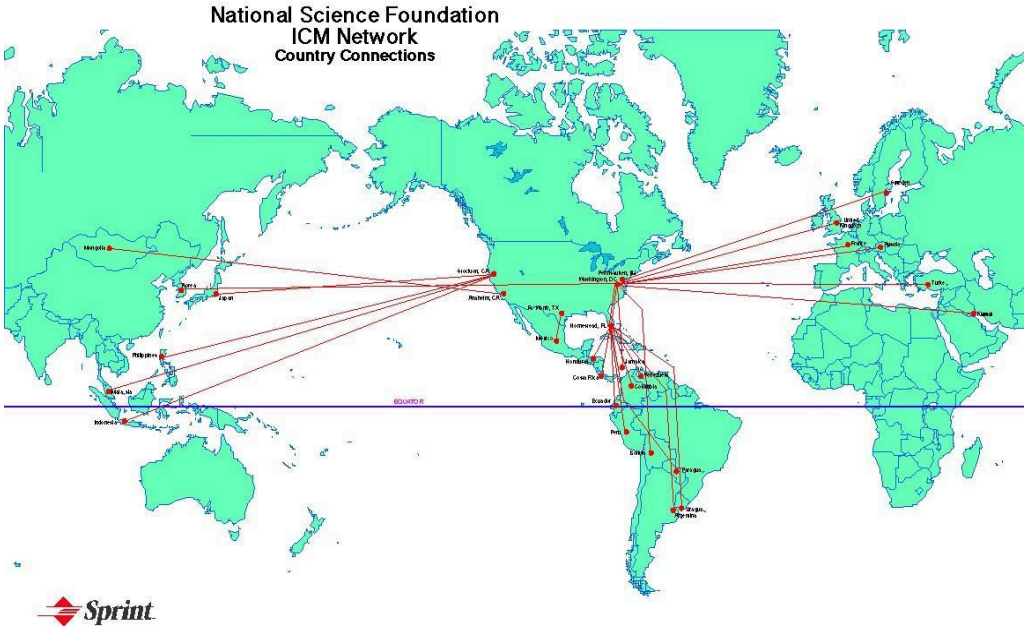

Figure 6-1. NSF International Connections Manager (ICM) 1991-1996 [Goldstein 2003]

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