# The Internet In Singapore:  A Benchmark Report

Larry Press, lpress@isi.edu

Outline:

## The Internet In Singapore:  A Benchmark Report

This report summarizes interviews conducted during July, 1997.  We made minor revisions; the most important being the addition of Appendix VI, assessing the state of the Singapore Internet at that time using our six-dimension framework.  This will provide background and a benchmark for a follow-up study during July 2000.

Singapore was selected for a national profile because of the close relationship between the government and industry, and because we felt they were committed to becoming a leader in networking after a somewhat late start.  Both of our assumptions appear to be true.  The national plan (IT2000) and aggressive funding for infrastructure building and education indicate a strong desire to become a leader in the field, and the government is actively involved in the enterprise as a planner and seed capitalist.

Singapore's commitment to networking and IT is illustrated the fact that their IDC/Worldtimes Information Society Index (ISI) score rose by 16.96% between 1996 and 1997 (Table 1).  Only Japan (18.86%) and Malaysia (17.65%) grew at a faster rate, and Singapore's ISI ranks 13 in the world.  Robust telecommunication growth is also shown in Appendix I.

| Table 1.  Singapore Information Society Index (ISI) | | | |
|---|---|---|---|
| **Infrastructure Type** | **1996** | **1996** | **Pct. Change** |
| Social | 267 | 282 | 6 |
| Computer | 1,481 | 1,859 | 26 |
| Information | 787 | 824 | 5 |
| ISI | 2,535 | 2,965 | 17 |

Source:  World Times, Information Society Index, 1996, 1997, World Times, Boston, 1997.

The National Computer Board of Singapore (NCB) and the Telecommunication Authority of Singapore (TAS) are leaders in the hybrid government-industry process. We will begin with descriptions of these organizations.  This is followed by a discussion of their involvement in IT2000 and the Singapore ONE (One Network for Everyone) infrastructure project.  We will then survey the three ISPs in Singapore, Pacific Internet, SingNet and CyberWay.  NCB and others realize that human capital is critical if they are to become an important regional and global IT power, and we discuss notable educational developments at the National University of Singapore and the Ministry of Education.  We also address work developing nations being done

by the Pan Asia project, and conclude with a description of the role of the Singapore Broadcasting Authority in regulating content and encouraging commerce.

There are also six sidebar/appendices showing demographic and telecommunication background, contacts in Singapore, a list of organizations active in the Internet industry, a list of international links and their characteristics, and a characterization of the state of the Internet in Singapore using the Mosaic Group framework.

**The National Computer Board of Singapore (NCB)**

This section describes the role and organization of the NTB.

Role

The NCB is part of the Ministry of Trade and Industry which is responsible for such things as trade, tourism, and industrial parks. It is a statutory board, which implies more flexibility in personnel policy than a civil service department or a government ministry. As a statutory board, they also have more financial freedom. They are allowed to retain equity in an organization that is corporatized, creating a separate legal entity owned by the government, or privatized, in which some or all of the ownership may be sold as stock.

For example, one of the original charters of the NCB was to develop government IT systems, but in April, 1996 that activity (1,000 IT professionals) was spun off as a wholly owned subsidiary company National Computer Systems (http://www.ncs.com.sg/). This left NCB with 488 employees, and a reduced role as an architect and catalyst, but they were no longer developers. The NCB retains a seat on the NCS board, and the ministry CIOs remain NCB employees. They plan to sell of their equity "soon."

Another example is Netrust (http://www.netrust.com.sg), a certification authority set up recently by NCB and NETS (a consortium of local banks which runs the EFTPOS and ATM network). Electronic commerce requires certification, but without substantial electronic commerce, a certification company is difficult to establish. To escape from this "catch 22," NCB formed Netrust, and will fund it while it establishes a market. Once it becomes profitable, they will sell back its shares (for their investment plus interest) and leave it to grow on its own. (Having government backing for a certification authority is also reassuring for the consumers).

In their catalyst role, the NCB acts something like a venture capitalist. They provide seed funding, but do not have a profit motive. (Neither do they expect to lose money on these investments). They do not take profits out of the companies they fund, and they only hope to recoup their investment plus a small, fixed percentage when they liquidate. It is like a soft loan to jump-start a strategic activity.

In 1995, they launched a $200 million IT Cluster Development Fund (CDF) and co-managed a $500 million Innovation Development Scheme (IDS) with the Economic Development Board of Singapore (EDB).[1] The CDF seeds or co-invests with local and foreign industry in projects in the following categories:

- continuous learning programs to help Singapore's IT professionals and users keep up with technological developments
- developing pioneering IT services and products
- prototyping new IT-related business concepts
- developing sector-wide information infrastructure

The IDS covers several industries, and NCB works with them on the IT projects. There is also an EDB program to groom promising local enterprises which are judged to have potential of becoming multinational corporations within five years.

The NCB role as an architect is illustrated by the formulation of the IT2000 plan and their work on Singapore ONE which is described below.

Organization

Today, NCB has roughly 700 employees organized as follows:

---

[1] Amounts are in Singapore dollars unless otherwise noted. At the present time, a Singapore dollar is roughly .7 US dollars.

```
                         NCB Board
                             |
                      NCB Management
                             |
   Government ──────────────┼──────────────  Information
   CIOs Office                                Technology
                                              Institute
   Center for Strategic ────┤
   Process Innovation        |
                             |
              ┌──────────────┼──────────────┐
              |              |              |
        Information     Functional      Clusters
        Infrastructure  Departments
```
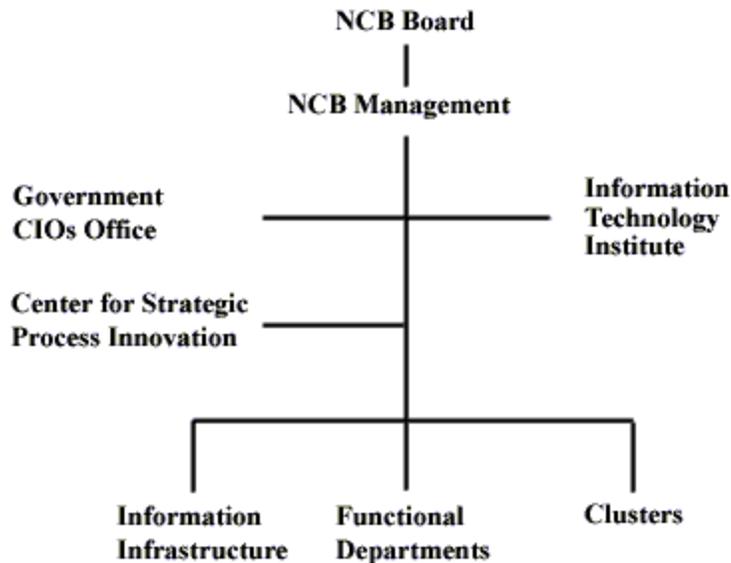
Although system development was spun off, the ministry CIOs remain NCB employees in the Government CIO Office.  Further trimming is planned.  The Information Technology Institute (ITI), the NCB research arm (200 employees), will be spun off and merged with the Institute of Systems Science (ISS) of the National University of Singapore.  The Center for Strategic Process Innovation is a small group responsible for assisting civil service agencies with organizational reengineering.

The functional departments are: Industry and Manpower Development, IT Culture Promotion, Corporate Plans, Corporate Communication, Human Resources, and Finance and Administration Services.

The clusters of flagship projects are: Construction, Digital Library, Education, Health care, Law and Justice, Manufacturing and Distribution, New Media, Public Services, and Tourism and Leisure.

The Internet Cluster (which had been grouped with new media) has recently been renamed the "Internet Competency Center," and moved to the Office of the Government CIO.  The old Internet Cluster had four thrusts:

*   connect and support government ministries
*   education
*   promotion of use of the Net by the public
*   operating the domain name registry, SGNIC

Some of this work is being scaled back.  Parts of the educational mission will be taken over by the Ministry of Education which has an ambitious five-year plan (see below).  SGNIC has just been spun off as an independent company.  They will allocate and charge for DNS registration and run a Whois database, but APNIC will provide numbers.  There will; however, be more emphasis on use of the Internet by the Government.

The NCB Policy Research Team tracks global NII efforts, publishing a monthly newsletter and maintaining an extensive archive of back issues and articles on intellectual property rights, issues relating to electronic commerce, security and encryption, privacy and data protection, content regulation, and access and service provision.  They also maintain an archive of national NII reports. http://www.ncb.gov.sg/nii/abt.html.

## Telecommunication Authority of Singapore (TAS)

TAS also plays a key role in Singapore telecommunications.  In addition to licensing telecommunication companies, they are a they set policy, lead and invest.  Their goals are consumer welfare, encouraging competition, and infrastructure and network development.

Like many nations, Singapore is moving toward increased privatization and competition.  In 1993 Singapore Telephone became a government-linked company (GLC).  GLCs are publicly listed, but the government is a major, if not majority, stockholder.  Between 1993 and 1996, 16.7% of Singapore Telecom was sold on the Singapore Stock Exchange and to foreign investors, raising $4.621 billion US.[2] Some shares have been reserved for Singaporeans who are encouraged to buy shares using their salary withholding fund.  Singapore now has three ISPs, two mobile phone companies, and four paging companies.  Qualified customers are also allowed to deal directly with satellite operators.

Singapore Telecom currently has a monopoly on telephone service, but TAS has called for proposals, and is now evaluating bids for up to two new telephone companies in the year 2000.  It is interesting to note that this step was originally planned for 2007, but to remain competitive in a rapidly changing

---

[2] ITU, "1996/7 World Telecommunication Development Report," International Telecommunication Union, Geneva, February, 1997.

telecommunications world, this date was pushed up.  Singapore Telecom will receive a lump sum $1.5 billion compensation for the introduction of competition.

TAS has licensed three ISPs, and they estimate that there are now 185,000 dial-up users (roughly 35% of Singapore's 800,000 households have personal computers) and 550 leased-line business customers.

The first licensed ISP was Singapore Telecom's SingNet.  Subsequently, Technet, the university and research network, was automatically given a license when it went commercial as Pacific Internet in September, 1995.  The third ISP, CyberWay, was selected from among six competitive bidders.  The competitors bid between $450,000 and $5,101,000 for licenses, but in spite of having the lowest bid, CyberWay was selected because it was felt the following features would benefit consumers:

- guaranteed account activation in less than 10 minutes after an order is placed
- the most competitive prices for a wider range of services
- the most comprehensive customer support services, including a 24-hour network operating center
- an aggressive marketing proposal

TAS sets quality of service standards for the ISPs to insure that they do not compete on price alone while sacrificing service.  Every three months the audit ISP performance in areas like network availability, system accessibility, customer support, traffic, etc.  Selected views of this data are available on the TAS Web server.

They also foresee rapid growth of networking and the convergence of voice, video, and other data types.  For that reason, they decided to take an active role as an architect and funding source for Singapore ONE.

**IT2000 and Singapore ONE**

As mentioned above, IT2000 is NCBs plan for an "intelligent island."  In 1986, a Committee on National Computerisation was formed to create a National IT plan.  In 1992, they published the IT2000 plan calling for the construction of a broadband networking infrastructure, common networking services (like directories, security, authentication, and billing), experiments with applications (national IT application projects), forging international strategic alliances with industry leaders in Japan, the EC and the US, and establishing a policy and legal framework on issues like data

protection, privacy, copyright and intellectual property rights, and the admissibility of computer-imaged documents in court.[3]

The goal is an intelligent island with high-speed connection to all homes, offices, schools and factories was set, with NCB responsible for coordination. In addition to providing efficient service and access to government, this infrastructure would make Singapore a test-bed for advanced applications and a global information hub. They hope to attract multinational business and service providers in entertainment, education, health care, etc., thereby boosting the economy, enhancing individual potential, facilitating intranational and international communities, and improving quality of life. NCB hopes to duplicate the success Singapore has had in coordinated efforts at becoming an important center for shipping and finance.

The June 1996 launch of Singapore ONE, the high speed networking initiative which is both an infrastructure investment project and an intriguing social experiment, was an important IT2000 milestone. Singapore ONE was begun by NCB (services and applications), TAS (infrastructure), NSTB (R&D), EDB (industry involvement), and the Singapore Broadcasting Authority (SBA, content). In September, an industry consortium called 1-Net was formed to build, own and operate the high speed network for Singapore ONE. Initially, 1-Net was owned by Singapore Communication Investments (SCI, 40%), a wholly owned subsidiary of TAS, Singapore Telecom (30%), and Singapore Cable Vision (SCV, 30%). In May, 1997, SCI sold 30% of 1-Net to ISPs Cyberway (15%) and Pacific Internet (15%).[4]

In March, 1997, a $5.9 million contract was awarded to Alcatel, and ATM switches have been installed at 8 locations on the island. Two central office (CO) switches have switching capacities of 35 Gbps and the six backbone access nodes (AN) 10 Gbps. Each access node node is connected to both CO switches at 622 Mbps. Links from ANs to service provider and access provider ATM switches can be at 155 or 622 Mbps. Pilot application servers and end users are on line now, and the backbone will be fully in place by the end of 1997.

End users will connect either via Singapore Telecom ADSL or a hybrid fiber cable (HFC) network being deployed by Singapore Cable Vision.[5] ADSL (up to 5.5 Mbps downstream and 168 Kbps upstream) will be available throughout the island by the

---

[3] National Computer Board of Singapore, "A Vision of an Intelligent Island," The IT2000 Report, SNP Publishers, Singapore March, 1992.

[4] Appendix III lists the complex ownership interrelationships in the IT area.

[5] MicroSoft is working with SCV on cable modems.

end of 1997 and the HFC network (neighborhood-shared 10 Mbps downstream and 785 Kbps upstream) will pass all Singapore apartments and condominiums (93% of the population) by the end of 1998.  The 60,000 private homes ("landed" properties) will have to make their own (costly) arrangements if they wish cable service.  It is also noteworthy that there is a conscious effort to install cable in poor neighborhoods first, to combat the problem of information haves and have-nots.

At present, 700 pilot households are connected, and they expect to have at least 5,000 homes and offices on line by the end of 1997.  During the pilot period, access and modem cost is being subsidized, but it is not free, and prices are not yet set for beyond the pilot period.  The official launch of services was in June, 1997.  It will be most interesting to watch this face-off between HFC and ADSL, to see how each is used and what the equilibrium prices are.

Sixty four pilot services are taking advantage of Singapore ONE's high speed connectivity.  Application categories are:  Shopping and Fun (20 applications), Learning (20), Information (16), and Government (8).  Shopping and Fun includes a variety of electronic shopping services, visits to tourist attractions, games, and entertainment.  Learning services are provided by a variety of private companies, universities and schools, and they include material for primary school through university programs and professional training.  The Information category includes library access, directories of people and organizations, medical information, and familiar search engines like Yahoo and AltaVista.  Regardless of the success of these ventures, the bread and butter "anchor" applications will be those of government agencies and Ministries.  Government services will be delivered to home and office PCs and to shared machines in community centers and interactive kiosks in high-traffic areas.

Singapore ONE has an aggressive plan to attract service and technology providers, and 29 multinational and 48 local corporations have already agreed to provide enabling technology or applications and services.  The incentives to these "Pioneer Club" members include grants (up to 70% of qualifying costs) from the government (EDB, NCB, TAS, NSTB, and SBA), tax incentives, preferential leased circuit tariffs, and publicity.  Subsidized server space is also available for smaller service and technology providers, and NSTB and its funded research institutes such as the Institute of Systems Science (ISS) of the National University of Singapore and the NCB's Information Technology Institute will provide technical leadership and the development of advanced multimedia applications.

Hoping to gain employment, exports, and technology transfer, the government has invested S$150 million in infrastructure and initiatives/incentives. Pioneer corporations have committed to invest more than S$200 million to develop innovative multimedia applications for Singapore ONE, and successful bidders for the two new telephone licenses will be expected to extend Singapore ONE by installing substantial backbones of their own.

The three ISPs will have 155 Mbps links, and they expect to recoup their investment from government services regardless of consumer acceptance. Singapore is a small market (the population is approximately 3 million) so consumer applications may need an international market to succeed -- the development of Singapore-specific content may be difficult to justify. They also speak of video on demand. While first run international movies may not be economically viable, Asian television and cinema, for example productions of the Television Corporation of Singapore, may be.

**ISPs**

Commercial networking in Singapore (and indeed Asia in general) began later than in the US, Canada, or Western Europe; however, they seem determined to catch up quickly. This section profiles Pacific Internet, SingNet, and Cyberway, the three ISPs licensed by TAS since 1995.

Pacific Internet (PI)

PI began as the university network, Technet, five years ago, and became commercial two years ago. They have approximately 85,000 analog dial-up customers and 300 corporate accounts (40% ISDN, 42% 64k, and 18% 128k). Like the other ISPs, they offer a variety of services including Web hosting, server collocation (< 5 customers), fax, pager and cell phone (text) gateways and Internet gaming. Their international links are three EI circuits to Japan and one third of a T3 to the US.[6]

PI differentiates themselves as selling the Internet as a lifestyle product, not a technical product. They co-market with large brands and channels like Macdonalds and supermarkets. They are also in early talks with various Web TV vendors. They are beginning to sell to housing developers with the intention of serving buildings. They are targeting vertical industries with their business marketing, for example, insurance, legal, shipping, and real estate companies.

---

[6] Appendix II summarizes all international links.

They also claim a more private-sector mindset as an organization than SingNet which they feel was shaped to some extent by its roots in what had been a government owned monopoly telephone company. They are more flexible and less bureaucratic.

Their Web site is the most visited in Singapore. They claim to receive 60 million hits per month, compared to 3.5 million for Cyberway and 15 million for SingNet.

SingNet

SingNet, the first commercial ISP, is a subsidiary of Singapore Telecom, which has a telephone monopoly until the year 2000, but operates at an arms length from them, and derives no advantage from the relationship. This impartiality is audited by TAS.

They offer much the same services as the others, with approximately 100,000 analog dial-up accounts, 3-400 ISDN accounts, and 2-300 leased lines. Their other services are Internet paging, mobile phone email, wireless access, Web hosting, Web co-location, fax gateway, and assigning domain names.

My subjective impression is that they may be a bit more engineering oriented and less attuned to commercial marketing than the other networks, but that was based on visits to only two back-office locations and one walk-in registration center.

SingNet is distinguished from the others in that they operate the Singapore Internet Exchange (STIX) which is seeking to become a leading regional hub. STIX peers with the other Singaporean ISPs and with several networks in the region. (While they would state who they exchanged traffic with, they were somewhat vague about which links were upstream, peering, and downstream).

The decision on whether or not to peer with someone is made on a case-by-case basis after study of traffic patterns. For example, they saw a lot of traffic between them and Japan was going through the US, and decided a direct connection to Japan would pay for itself. Peers each pay for one half-circuit, and do not charge each other. Downstream customers pay for the entire circuit, plus fees.

STIX has 37 links to 24 nations. The difficulty in building an intranational backbone is illustrated by Indonesia which has three STIX customers who are unwilling to cooperate with each other. A big ISP does not want to subsidize his competitor by allowing them to achieve a lower communication cost, and the small ones do not want to advertise that they connect through a larger competitor.

Their Competition is A-Bone in Japan, Net Plus from Hong Kong Telecom, and KDD. A-bone has fewer than 10 customers, all at 2 mb. Net Plus has a similar mix to STIX: 64k-1.5m. KDD has around 60 ISPs and exchanges traffic with Asia, Australia (Telstra) and New Zealand. A list of IXs maintained at http://www.isi.edu/div7/ra/NAPs/naps_ap.html shows the following IXs in the region:

  HKIX - The HongKong Exchange
  NSPIXP-2 - (In Japanese!)
  IMnet - From NTT & KDD (under development)
  NZIX - Neutral New Zealand :)
  STIX - Singapore Telecom gets into the act
  MM-MAP - Metro Manila (Philippines)
  Western OZ Internet Exchange
  AUIX - Some Australian Exchanges which seems to be limited to
  being an Australian ISP peer point)

CyberWay

CyberWay is the newest ISP. They are owned by SPH and STEC. Unlike the other two ISPs, they competed for their license, and won on the basis of their emphasis on customer service and support. CyberWay's one-time licensing fee of $450,000 was imposed retroactively on the first two ISPs to level the playing field.

CyberWay offers the same array of services as the others, and has 35,000 analog dial-up customers. They have a 15 Mb/s link to Canada and a 256k link to Japan. (Fifteen percent of their traffic is within Singapore). CyberWay stresses strong marketing and customer service. Examples of their marketing programs are:

• lower rates on weekends
• reselling through 26 partners (VARs) who specialize in schools and other businesses (customers include government, SBA, NCB, IBM, NTT, banks, etc.
• direct sales force for business accounts
• free (1 MB) home page for all customers (<10% use it) and a search engine for finding the home pages of people with various interests -- community building
• CD-ROM with $200 software with sign up
• web development tools to support people with home pages
• mirror site for Two-Cows and Simtel

- Personal News Watch -- selected News groups (not sure how this works -- it may just be a .newsrc file for Usenet News with a news reader)
- registration centers in department stores, cyber cafes, computer stores, events like the Singapore Book Fair, etc. -- accounts are activated within 10 minutes and the store gets a commission
- They are the leader in meeting QOS requirements of the TAS. (TAS discusses QOS on their Web page, but there is little information of value to a potential customer).

## IT Education

Press[7] discusses gating factors for network development in a nation. These include the availability of both specialized networking technicians and a nation of trained, demanding users. The latter are the toughest nut to crack because they require motivation, ubiquitous IT, and changes in culture and work habits. (Perhaps the most important networking "infrastructure" in the U. S. is the legions of PC users who are familiar with games, word processing, email and other simple applications). Singapore is addressing both of these needs. The universities are producing technicians and a five-year Ministry of Education (MOE) master plan addresses the latter. This section discusses networking programs at the National University of Singapore (NUS) and the Ministry of Education (MOE) five year plan for IT in education.

National University of Singapore (NUS)

The NUS Computer Center led early networking activity in Singapore. Their Internet Research and Development Unit (IRDU) built Technet, which was spun off as Pacific Internet. They are now responsible for university connectivity including the Internet 2 project and a forthcoming link to Singapore ONE.

The ISCS Department at NUS is large and of high quality. There are three divisions: Computer Science (theoretical), Information Systems (relatively small -- 10 staff), and Information Technology. The department is part of the Faculty of Science, which also has a Department of Computational Science. ISCS has 1,500 undergraduate students, 24 PH.D. students, 90 M.Sc by research and 120 M.Sc by coursework. (The latter are primarily part time students working in industry who attend class in the evening). Nearly half of the Doctoral students are foreign. There

---

[7] Press, L., "The Role of Computer Networks in Development," Communications of the ACM, Vol. 39, No. 2, pp 23-30, February, 1996.

are 72 academic staff, 12 post docs, and 25-30 teaching assistants. Since its formation, ISCS has supplied approximately 25 percent of the IT manpower needs of Singapore. The programs have a rigorous core and emphasize practical projects and preparation for work.

NUS is an Internet 2 participant. They will have an ATM link to one of the Singapore ONE switches, and there will be a 15 Mbps link from there to the NSF STAR POP in Chicago, which is on the vBNS. This link will be subject to NSF acceptable use policy, restricting it to use by Internet 2 projects, which in turn must involve collaborating researchers in Singapore (funded by the NSTB) and the US (funded by the NSF). The NUS Internet proposal is at http://www.sren.irdu.nus.sg/, but is currently password protected.

An important side-effect of this project will be the ATM link from NUS to Singapore ONE. All university traffic will be routed over that link, which is important because the university has only a 64 Kbps link today, which is excruciatingly slow. (The ISCS department operates its own dial-in server so students and faculty can access the campus from home without going through that link).

While this project is funded explicitly for support of collaborative research between scientists in the U. S. and Singapore, it will also provide experience with high speed infrastructure. Technicians such as Dr. Ananda are being trained, and TAS mentions the high-speed link to the STAR POP as a national asset in their Singapore ONE presentation (in spite of the AUP).

Another illustration of university-based training and infrastructure development which may find application on Singapore ONE is an ATM-based (not IP) multicasting project. They two-way, many-many audio-visual conferencing with user-tunable quality of service. While the demo was far from a packaged product, they envision applications in education, meeting support, and delivery of video on demand, and, have funding and participation from NCB, ISI, Singapore Polytechnic, and some commercial companies.

Ministry of Education (MOE)

In April, 1997, the MOE announced a five-year, $2 billion master plan for IT in Education http://www.moe.edu.sg/new/mite.htm. This master plan covers primary schools (grades 1-6), secondary school (7-10), and junior colleges (11-12).

The plan is intended to be a blueprint for the use of IT in schools and also provide for connectivity. The goals of the plan are the enhancement of linkages between schools and the rest of the world, innovation in education, enhanced creative thinking, lifelong learning and social responsibility, and excellence and efficiency in education administration. The plan provides for:

- redesigned curriculum and assessment with more emphasis on active and independent learning and mastery of concepts and skills as opposed to acquiring factual knowledge
- development of educational software and the use of the Internet in teaching and learning
- providing training and equipment to teachers
- connectivity, computers, and related resources in schools and at home

The five year plan has begun with pilot work in 22 demonstration schools. Additionally, the Teachers-On-Line program is establishing network connectivity as part of the school culture. This program uses the Web, listservers and chat for two-way communication with teachers. All teachers are entitled to a free Internet account (18,053 of 22,000 teachers had accounts as of May 5, 1997), and they are given grants toward the purchase of home computers. They are encouraged to communicate with each other and with the Ministry of education using the Net.

During 1998 90 more schools will come on stream and the remaining 250 in 1999. By the year 2000, all teachers in every school will be trained. By 2002, there will be a 2:1 pupil-computer ratio in schools, they will all be connected to Singapore ONE, and 30% of the curriculum time will be IT-based. This program will surely affect the skills and expectations of the general user community, and it will be fascinating to see the effects.

## Developing Nations

The Pan Asian Networking (PAN) project is working toward connectivity in developing nations. PAN is run by the International Development Research Centre (IDRC) a major Canadian donor to developing nations. IDRC runs a sister project called ACACIA, http://www.idrc.ca/acacia/, in Africa and they are just beginning the Pan Latin American project. Pan Latin America will be headed by Gilles Cliche, gcliche@idrc.ca.

PAN was started in 1993 and approved by IDRC in 1994. It provides:

*Minimal connectivity in nations with none.*  They fund the startup of an ISP, who must show a business plan which promises to establish them as a self-supporting company in a reasonable time.  These have been established in Mongolia, Laos, Cambodia (no service yet), Vietnam, Sri Lanka, and Bhutan (no service yet).  Mongolia is the most successful.  They began with a UUCP link and now have a 128 Kbps IP link.  They uses a variety of funding models, including grants and loans in return for equity.

*Content provision.*  Content providers are given servers and support for gathering and posting content.  These tend to come from the wealthier nations.  They get some training in Singapore, but IRDC is very sensitive to the need to raise the skill level of people in target nations.  For that reason, they do not host content, but merely link to it from their server.  Content has been developed in the Philippines and Nepal with Vietnam coming soon.

*Communication.*  They held a successful conference for the 105 people who are actively working on Pan Asia in Mongolia recently.  Eleven listservers for specific communities continue the activity begun at this conference.  The proceedings are at http://www.PanAsia.org.sg/conf_001.htm.

*They also publish news releases and descriptions of their projects.*  In 1995, they published a book of Asian nation reports.[8]  That book covers Bangladesh, Cambodia, Philippines, Sri Lanka, and Vietnam.  They hope to broaden the coverage and publish this book annually.  (They feel it can be self sustaining).  They have done a sample chapter for the ongoing book (on the Philippines), and have proposed the project to IDRC management.  It is not yet funded, but they are hopeful.

*Research and Development.*  They are accepting proposals for related R&D projects from people in their client nations.  The hope is that Asia can make original and valuable contributions rather than following the western lead.  This activity will begin in October, 1997, and the annual budget will be $Canadian 500,000.

**The Singapore Broadcasting Authority (SBA) -- Content Regulation and the Encouragement of Commerce**

The SBA was formed in 1994 with the goals of developing quality broadcasting, building a well-informed and culturally rich society, and making Singapore a

---

[8] Garton, Andrew, Parikh, Jagdish, Nanda, Suchit, and Fernandez, Leo, "Pan Asia Networking: An Asian Survey," IDRC, Ottawa, 1995.

dynamic broadcasting hub.  (Note that they have an economic growth goal).  The Internet falls under their jurisdiction, and they license ISPs and content providers, and they regulate content with what they call a "light-touch" emphasizing self regulation.

ISPs operate proxy servers which screen out certain Web pages.  the primary selection mechanism is consumer complaints, which SBA follows up on.  The ISPs are required to remove content when the SBA directs them to do so.

The primary responsibility for content lies with the creator, and large content providers are required to comply with SBA's Internet Code of Practice, http://www.sba.gov.sg/netreg/govgaz/code.htm.  The Internet Code of Practice is concerned with information affecting public security and national defense, racial and religious harmony, and public morals.

Private individuals with Web pages are exempted from licensing and regulation unless they have "high-impact" pages for business, political or religious purposes. Software developers are not affected by the regulations.

While Singapore is known for their proxy servers, the SBA also has an economic expansion goal, and toward that end, they are working on policies regarding intellectual property (One sees bootleg software and $15 "Rolex" watches for sale at outdoor market places), security, digital signatures, and privacy.  These will enhance Singapore's ability to attract developers and capital and conduct electronic commerce.  Services to support security and privacy, and facilitate commerce will be provided on Singapore ONE.

**Conclusion**

Singapore has aggressive plans for networking and a close relationship between government and industry.  The government clearly sees the Internet as a strategic infrastructure and a segment to be nurtured (along with water, oil, power, telecommunications, housing, and others).  Singapore's domestic market is small, so they are forced to concentrate on multinational enterprise.  The Internet is clearly both a multinational enterprise in its own right and infrastructure necessary to support other multinational enterprises.  Their focus on the Internet as a strategic resource is evidenced by the IT 2000 plan, the IT education plan, Singapore ONE, and STIX.  A high probability of success of Singapore Inc. on the Internet is indicated by the commitments already made, their internal education program, the

organizations they have in place, a high national savings rate (see Table 2) and fiscal solvency, and excellent complementary industries.

## Table 2. Gross Domestic Investment and Savings, 1995

| Nation/Region | GDI as % of GDP | GDI growth rate | GDI/Cap | GDS/Cap |
|---|---|---|---|---|
| Singapore | 33% | 8% | $9,291 | $14,439 |
| Japan | 29% | 0% | $11,828 | $12,459 |
| Malaysia | 41% | 18% | $1,719 | $1,575 |
| United States | | 3% | | |
| High income | 21% | | | |
| South Asia | 23% | 11% | | |
| Upper middle income | 21% | -1% | | |
| World | 23% | | | |

Source: World Bank, World Development Indicators, Washington, 1997.

The government-industry relationship is closer in Singapore than the US. The US government played a key role in the development of computing and networking (Table 3). They encouraged development by procurement, notably in the construction of SAGE (Semi-Automatic Ground Environment), a system to defend against manned bomber attacks, and in funding research and development with a secondary motivation of procurement, notably ARPANET. The direct return to companies working on these contracts is modest, and commercialization follows as they capitalize on their knowledge or new firms are started, often with venture capital.[9]

## Table 3. Cost estimates for US seeding of networks.

| Project | Federal Funding (Million $) | Primary Motivation |
|---|---|---|
| Morse Telegraph | 0.03 | R&D |
| SAGE | 8,000.00 | procurement |
| ARPANET | 25 | R&D |
| CSNET | 5 | procurement |
| NSFNET Backbone | 57.9 | R&D |
| NSF Higher-ed connections | 30 | procurement |
| NSF International connections | 6.6 | procurement |

---

[9] Press, Larry, "Seeding Networks, The Federal Role," Communications of the ACM, pp 11-18, Vol 39, No 10, October, 1996.

In Singapore, the government plans, picks strategic industries, and acts as a venture capitalist. They also leverage procurement, for example with the computerization of government offices in the past and now with planned use of Singapore ONE and investments in education. The government is like a large department store "anchoring" the Singapore ONE "mall." Unlike the US, the government often retains equity and a management role in operational commercial enterprises. (Appendix V presents an example of a project in which the US NSF is seeding what will become a self-sustaining activity, but without an equity position).

The dangers with the government picking companies and industries to subsidize and operate are that they make choices the market does not support and that inefficient bureaucracy may interfere with effective operation. In this case, the freer capital markets are also investing heavily in the Internet, so the government choice seems reasonable. There are also means of fighting bureaucracy. Statutory Boards such as the NCB are something between government departments and private companies. They have the possibility of making profit and accumulating wealth which they control. NCB provides an example of willingness to downsize rather than protect a bureaucracy as might be expected. They have spun off their government systems implementation (1,000 people) and will spin off their research (200 people). Even the Internet Cluster is being closed down, and the new Internet Competency Center is spinning off DNS registration and much of its educational activity. Such downsizing is uncommon in government.

The government funding mechanism is also inherently conservative. New ventures are often established by existing organizations with good connections and track records. There is also the possibility for favoritism or corruption, though I heard no such allegations while there. One means of guarding against them is to offer high pay and status for government service, which Singapore does.

We cannot project Singapore's success into the future or to other Asian nations. Singapore is both small and wealthy relative to most nations in the region. Demographic, economic and telecommunication indicators place Singapore among the developed nations of the world.

There is also a history of benevolent social engineering. For example, housing projects are designed to integrate races and income levels, all newspapers are owned by SPH (there are 7 daily papers, 3 in Chinese, 2 in English, 1 in Malay and 1 in

Tamil), and there is an attempt to control access to material on the Internet.  During the week of interviews for this study, we noted a television campaign encouraging people to be courteous, something reminiscent of the US in the 1950s, and we learned of a campaign to encourage people to take more interest in art and culture.

Singaporeans refer to themselves as "economic animals," an assertion borne out by their success and the abundance of goods and services.  (We were told that Mercedes Benz is the most widely owned auto in Singapore).  There is a strong willingness to save.  Twenty percent of ones salary (matched by the employer) goes to a fund which is used for retirement, housing, education, health care, etc.  Future generations may make different personal and economic choices.  This is perhaps vaguely foreshadowed in the frequent, somewhat self-conscious references one hears to the uniformity of government constructed apartments, minor offenses for which they may be fined, and Singapore's control over Internet content.

Regardless of gradual social change and the uncertainty of market acceptance for their investments, it would seem a safe bet that Singapore will be a key player in the diffusion of the Internet in Asia.  We will all learn valuable lessons by watching their experiments.

**Sidebar/Appendices:**

I.   Demographics and Telecommunication Infrastructure
II.  International IP Connectivity to and from Singapore
III. Singapore Inc's Internet Connection
IV.  Singapore Networking Contacts
V.   CAIDA Funding Model
VI.  Mosaic Group Dimension Values


I.  Demographics and Telecommunication Infrastructure


Table 4 shows selected telecommunication and demographic indicators.  Singapore is a city/nation, located on an island.  It is the third most densely populated economy on earth at 4,848 people/square kilometer.  Only Macau (26,527) and Hong Kong (5,829) exceed Singapore's population density.  As of 1997, Singapore has essentially the same GDP/capita as the US, however there is less evident poverty due to a more equal income distribution (roughly 85% of Singaporean's own their homes).  This degree of affluence is remarkable when one considers that the nation was founded in 1965, and in 1970 the US GDP/capita was nearly five times that of Singapore ($4,960 vs. $1,050).  Singapore's 1995 GDP growth rate per capita was 9%.  The United Nations Development Program publishes a national Human Development Index (HDI) which is a function of life expectancy, adult literacy, combined secondary and tertiary school enrollment and real GDP per capita.  Singapore ranked 26th in the world in 1994 HDI, and should rise rapidly due to their education master plan and economic growth.


## Table 4: Selected Telecommunication and Demographic Indicators

|  | Singapore | Europe | HongKong | U.S. | Japan |
|---|---|---|---|---|---|
| Population (M) | 2.99 | 791.98 | 6.19 | 263.12 | 125.21 |
| Population density (per km2) | 4,848 | 33 | 5,829 | 28 | 331 |
| GDP/cap (US$) (1994) | 23,724 | 10,863 | 22,970 | 26,622 | 37,563 |
| Telcom Exports $M US | 2,272 | 24,481 | 240 | 10,989 | 6,999 |
| Telcom Exports/M US$ | 760 | 31 | 39 | 42 | 56 |
| Telcomm Imports $M US | 1,805 | 20,018 | 5,218 | 10,884 | 3,114 |
| Telcomm Imports ($/c) | 604 | 25 | 843 | 41 | 25 |

| | | | | | |
|---|---|---|---|---|---|
| Phone lines/100c | 47.85 | 32.95 | 52.96 | 62.57 | 48.8 |
| Cellular sub/100c | 9.77 | 3.04 | 12.9 | 12.84 | 8.15 |
| 94-5 phone line growth rate | 7% | 4% | 4% | 5% | 2% |
| 94-5 cellular growth rate | 24% | 60% | 65% | 40% | 136% |
| Telecomm investment/$c | 146 | 62 | 188 | 90 | 283 |
| Telecomm revenue/$c | 850 | 247 | 826 | 677 | 747 |
| Intl outgoing  traffic (min/c) | 258.8 | 36.2 | 273.3 | 59.5 | 13.1 |
| Intl circuits k | 10.4 | 411.4 | 33 | NA | 28.9 |
| Intl circuits/100c | 3.48 | 0.52 | 5.33 | NA | 0.23 |
| Life Exp at birth (yrs) (1994) | 77.1 | NA | 79 | 76.2 | 79.8 |
| Adult literacy rate (1994) | 91% | NA | 92% | 99% | 99% |
| HDI index (1994) | 900 | NA | 914 | 942 | 940 |
| HDI rank  (1994) | 26 | NA | 22 | 4 | 7 |
| Internet hosts (1997) | 41,015 | NA | 71,405 | 9,330,410 | 780,702 |
| Internet hosts/100c | 1.37 | NA | 1.15 | 3.55 | 0.62 |

Currency figures are in US dollars and figures are for 1995 unless indicated differently.

Sources:

Internet hosts:  Matrix Information and Directory Services, "Matrix Maps Quarterly," January, 1997.

Life Expectancy, Literacy and HDI:  UNDP, United Nations Development Programme Report on Human Development, Oxford University Press, Oxford, 1997.

Others:  ITU, "1996/7 World Telecommunication Development Report," International Telecommunication Union, Geneva, February, 1997.

As a major industrial and training center, Singapore is heavily invested (per capita) in all areas of telecommunications infrastructure, and with up to two new telephone companies in the year 2000 and an ambitious data networking program, their telecommunication density should grow.  As Table 5 shows, Singapore has high rate of leased circuits to/from the US.  Leased circuits tend to be used for data communication and switched circuits for conversation.

**Table 5.  Numbers of leased, switched, and idle 64Kbps circuits to and from the US.**

| | Leased | Switched | Idle | Leased Pct. |
|---|---|---|---|---|
| Canada | 5,543 | 44,172 | 1,936 | 11% |
| Mexico | 1,653 | 23,416 | 800 | 7% |
| Hong Kong | 800 | 742 | 1,036 | 52% |
| Singapore | 521 | 306 | 593 | 63% |

| World | 26,497 | 126,150 | 118,343 | 17% |

## II. International IP Connectivity to and from Singapore

Singapore is an international financial, trade and shipping center, and sees international connectivity as a priority.  The primary upstream link is a 45 mbps like to North America which is shared by the three ISPs.  The three ISPs share traffic today on 2 mbps links within the country today, but that will be cut over to Singapore ONE, with the current links remaining in place as backup and redundancy.  STIX hopes to be a major upstream provider for smaller networks in the region.

| Nation/Relationship | City | Carrier | Speed | Notes |
|---|---|---|---|---|
| **CyberWay** | | | | |
| Upstream Providers: | | | | |
| Canada | Vancouver | Worldcom | 15m | |
| Japan | Tokyo | KDD | 256k | peer? |
| **Pacific Internet** | | | | |
| Upstream Providers: | | | | |
| Canada | Vancouver | Worldcom | 15m | |
| Japan | Osaka | AIH (A-Bone) | E1 | peer? |
| Japan | Tokyo | AIH (A-Bone) | 2E1 | peer? |
| **SingNet (STIX)** | | | | |
| Peering Partners: | | | | |
| Australia | Sydney | Connect.com | 128k | |
| China | Beijing | China Telecomm | 128k | |
| Hong Kong | Hong Kong | Hong Kong Telecom | 128k | |
| India | Bombay | VSNL | 64k | |
| Japan | Tokyo | ITJ | 256k | ? |
| Japan | Tokyo | KDD | 1920k | ? |
| Japan | Tokyo | IDC | 256k | ? |
| Korea | Seoul | Korea Telecom | 128k | |
| Malaysia | Kuala Lampur | Malaysia Telecom | ??? | |
| Taiwan | Taipei | Chong Hua Telecom | ??? | |
| Upstream Providers: | | | | |
| Monaco | Monaco | UUNET to Ebone | 2m | |
| Canada | Vancouver | Worldcom | 15m | |
| Canada | Montreal | | 2m | |

| | | | |
|---|---|---|---|
| Canada | Montreal | | 2m |
| USA | San Francisco ? | MCI | 4m |
| USA | Los Angeles ? | ANS | 4m |

Downstream Customers:

| | | | |
|---|---|---|---|
| Bangladesh | Dakah | 64k | |
| Bangladesh | Dakah | 64k | |
| Bangladesh | Dakah | 64k | |
| Brunei | Bandar | 384k | |
| Indonesia | Jakarta | 128k | |
| Indonesia | Jakarta | 192k | |
| Indonesia | Surabaya | 512k | |
| Laos | | UUCP | Pan Asia? |
| Mauritius | | UUCP | Pan Asia? |
| Nepal | Katmando | ??? | |
| New Caldonia | Noumea | 128k | |
| New Caldonia | Noumea | 64k | |
| Pakistan | Lahore | 128k | |
| Pakistan | Lahore | 64k | |
| Pakistan | Karachi | 64k | |
| Pakistan | Karachi | 64k | |
| Philippenes | Manila | 128k | |
| Sri Lanka | Colombo | ??? | |
| Thailand | Bangkok | 128k | |
| Vietnam | Ho Chi Minh | PPP | |
| Cambodia | Phnom Phen | UUCP | Pan Asia? |

III.  Singapore Inc's Internet Connection

The following is a summary ownership percentages of the interconnected web of organizations working on the Internet in Singapore:

1N: 1-Net, a consortium of TAS, ST, SCV, PI, and CW which will run the Singapore ONE project and operate the initial ATM backbone.

CW: Cyberway, an ISP owned by SPH (50%) and STEC (50%). http://www.cyberway.com.sg/.

EDB: Economic Development Board of Singapore works to attract capital and brainpower and cooperates on the funding of projects like NCB cluster flagship applications and in attracting developers to Singapore ONE. http://www.sedb.com/index1.html.  (Note that this is a US mirror -- one of their major goals is attracting foreign capital).

GETIT: A telecommunications consultancy working with both policy and technical issues, headed by Laina Raveendran Greene (liana@getit.org, 778-5637 h, 738-6929 o) wife of Barry Greene of Cisco, an early SN principle.  http://www.getit.org/.

IDRC:  The International Development Research Centre a major Canadian donor to developing nations.  http://www.idrc.org.sg/.

IRDU: Internet Research and Development Unit of the National University of Singapore, developed Technet, Singapore's first Internet network and now working on connectivity to Singapore ONE and Internet 2.  http://www.irdu.nus.sg/.

ISS: The Institute for System Science of the National University of Singapore, does research, development and training, often in collaboration with industry. http://www.iss.nus.sg/.

MOE: The Ministry of Education, which has an ambitious five-year plan for IT-based education in all schools.  http://www.moe.edu.sg/.

NCB: The National Computer Board of Singapore plays a key role in IT planning and in providing capital for strategic development work.  http://www.ncb.gov.sg/

NSTB: The National Science and Technology Board is the "NSF" of Singapore. They fund a fixed percent (approx. 2%) of GDP for research and development and are involved in infrastructure provision as well.  http://www.nstb.gov.sg/.

NUS: The National University of Singapore established the first Internet connectivity in Singapore and is establishing an Internet 2 link with NSF.  http://www.nus.sg/.

PA: The PanAsia project of IDRC, which is providing connectivity, developing content, and sharing information with the very poorest nations in the regions. http://www.PanAsia.org.sg/.

PI: Pacific Internet, the first commercial ISP, originally spun off from NUS, now owned by SM.  They are also a partner in the Asia-1 backbone consortium. http://www.pacific.net.sg/.

SBA: Singapore Broadcasting Authority, regulates Internet content and working on policy for privacy, security and intellectual property.  http://www.sba.gov.sg/.

SCV: Singapore Cable Vision, a CATV company deploying a hybrid fiber cable network which will pass all of the 800,000 homes in Singapore by 1988.  SCV is a joint venture between SPH and Continental Cablevision.  http://www.singa.pore.net/.

SGNIC: Singapore Network Information Center is a wholly-owned subsidiary of NCB, and is responsible for domain name registration, maintenance or relevant databases, etc.  http://www.nic.net.sg/.

SH: Sembawang Corporation is a holding company with interests including shipping, construction and media.  It is a GLC.

SM: Sembawang Media, a media company owned by SH.  They own Pacific Internet, a majority interest in ISP Hong Kong Supernet, a multimedia production company, web publisher, financial information provider, internet cafe, and Inter/intranet consultancy.  http://www.smedia.com.sg/

SN: SingNet an ISP which is a department of ST, but operates at arms length.  (TAS enforces this).  http://www.singnet.com.sg/.

SPH: Singapore Publishing Holdings, the publishing company which owns publishes 11 newspapers and 8 magazines (including the only daily newspaper in Singapore) in Singapore and nations in the region.  In addition to owning CyberWay, they have a

multimedia production company, operate the AsiaOne web site, own 35% of the MobileOne cellular service, and are bidding on a telephone license. http://www.asia1.com/asia1home/sph.html.

ST: Singapore Telecom, the Singapore telephone company which has been privatized (roughly 18% has been sold off) and will face competition after the year 2000. http://www.singtel.com.

STEC: Singapore Technologies 15,000 person technology conglomerate.  It is a GLC.  http://www.st.com.sg/.

STIX: The Singapore Internet Exchange, an IX which peers with several major networks and sells to downstream ISPs in the region, owned by SN. http://www.stix.net/.

TAS: The Telecommunication Authority of Singapore licenses and regulates telecommunication and Post and is a catalyst and policy maker. http://www.tas.gov.sg/.

TH: Tamasek Holdings, a government-owned holding company.  (It merely owns, but does not operate companies).

IV. Singapore Networking Contacts

The following are people I met or spoke with on the phone during the visit. Where appropriate, I also indicate who each was referred by (RB).

NCB

Marc Tan, marctan@ncb.gov.sg, until July the head of the New Media and Internet Cluster, now responsible for Corporate Communication.

Quah Cheng Hai, chenghai@ncb.gov.sg, who has replaced Marc.

TAS

Regarding Singapore ONE:

Foo Jong Ai, foojai@tas.gov.sg, 322-1813, Director Multimedia Development. RB Marc Tan and invited the following to the meeting:

>Chua Kian Soon, kschua@tas.gov.sg, 322-1834, Project Engineer (Infrastructure Development).

>Tan Kuan (Ms), tankuan@tas.gov.sg, 322-1832, Project Officer (Infrastructure Development).

Regarding Policy and Regulation:

Fiona Yeo Su Ling, fiona@tas.gov.sg, 322-1824, Senior Officer Industrial Policy.

Audrey Lee Li-Fung, audreyl@tas.gov.sg, 322-1861, Assistant Director (Industry Policy) Policy Directorate

Lena Tan, lenatan@tas.gov.sg, 322-1860, Policy Officer (Industrial Policy).

ISPs

Pacific Internet

Nicholas Lee, nicklee@pacific.net.sg, 771-0788, CEO, RB Foo Jong Ai.

Debbie Woon, debbiewn@pacific.net.sg, 771-0727, Marketing Mgr., RB Marc Tan and Nick Lee.

SingNet

Tang Chang Thai, tchangth@singnet.com.sg, ADSL technical information and rollout.  RB Marc Tan.

Seo Boon, seong@singnet.com.sg, 471-9800, network engineer, #2 Sterling Road, nice guy, no card.  Boon RB Chang Wai Leong, cwl@singnet.com.sg, RB Marc Tan.

Ong Wee Cheong, ongwc@singnet.com.sg, mgr. of Business Development, not so forthcoming.  RB Khatijah Sultan and Vivien Chiam.

Tang Chang Thai, tchangth@singnet.com.sg, ADSL rollout and technical information, RB Marc Tan.

CyberWay

Cheah Cheng Poh, General Manager, cheacp@cyberway.com.sg, RB Foo Jong Ai.

Wee Way Kiat, waykiat@cyberway.com.sg, 843-4800, VP Sales. RB Marc Tan.

Cheng Kong Chit, chengkc@cyberway.com.sg, 740-1691, VP for Technology and Networking. RB Marc Tan.

National University of Singapore

Chua Tat-Seng, chuats@iscs.nus.sg, 772-2505, Acting Head, Department of IS and CS.

Pung Hung Keng, pungkh@iscs.nus.sg, 772-2808, Technology Coordinator working on ATM multicast project.

A. L. Ananda, ananda@iscs.ics.nus.edu.sg, http://www.iscs.nus.edu.sg/~ananda, 772-2733, Associate Professor, working on the Internet 2 project.

Tan Tin Wee, tinwee@irdu.nus.sg, 772-6490, Head IRDU, Assistant Director of the NUS Computer Centre, and Chairman of the Asia Pacific Networking Group.

MOE

Yeo Hong Mui, yhm@moe.edu.sg, 460-5406, RB Kuda Vidanage.

Kuda Viderage, educational consultant at NCB, kuda@ncb.gov.sg, 772-0509, RB Professor Ananada.

The Pan Asia Networking Program

Maria Ng Lee Hoon, MariaNgLeeHoon@idrc.org.sg, 235-1344, Coordinator.

Vivien Chiam, vivien@idrc.org.sg, 235-1344, Manager, Business and Partnership Development

Singapore Broadcasting Authority

Ms. Ling Pek Ling, pekling@sba.gov.sg, 373-0803, Director of Policy and Planning, RB Marc Tan.

V.  CAIDA Funding -- Mixing the Singaporean and US Models

The Cooperative Association for Internet Data Analysis (CAIDA),
http://www.nlanr.net/Caida/, has been funded by NSF to gather data on network
performance, availability and traffic for the benefit of users and network operators.

CAIDA's organization and funding structure has elements of Singapore and the US.
The NSF is providing seed funding for CAIDA, and it is anticipated that it will be
"spun off" as a self-financing non-profit corporation in three years, but NSF
will not retain equity or control as would be the case in Singapore.

CAIDA will have member organizations (for example ISPs), and some of the data
they gather will be available only to members, other will be for sale to customers,
and overall aggregate data will be available to the public.  This three-tier structure
makes CAIDA part industry association, part business, and part government research
lab

It may be argued that government support is unnecessary in a case like this.  If there
is a need for network measurement, the ISP industry could fund a trade association or
someone (perhaps the same people) could start a profit-making business to gather
and sell information to ISPs and other interested parties.  NSF is playing the role of
venture capitalist, but they will not retain
equity and reap the benefit of a lucrative public stock offering or pass along a tax cut
to the citizens.

Will there be public benefit?  The publicly available data is one concrete benefit.
Hopefully this will go far beyond a few statistics in a monthly press release -- there
should be substantial on-line data and analysis geared to the user and research
communities.  This funding also gives competing ISPs an
incentive to cooperate in the critical area of data collection and analysis, which
should lead to a better optimized Internet, from which we all benefit.  (The public has
surely benefited from earlier government seeding of networks.[10]

Less tangibly, this seed funding gives the public and scientific community a seat at
the management and policy making table for Net measurement.  After NSF funding
is withdrawn, the organization culture and further sponsored research may keep this

---

[10] Press, Larry, "Seeding Networks, The Federal Role," Communications of the
ACM, pp 11-18, Vol 39, No 10, October, 1996.

influence alive.  If that is not the case, perhaps a critical function like this should be regulated.  A competitive market and regulation are two mechanisms for public influence over organizations, but in this case, there would not seem to be an opportunity for competition or even oligopoly -- how many CAIDAs can there be?  We should be judicious in suggesting regulation, but it may be desirable.  If it were, the next question would be who should the regulator be?  The US government is surely not the only candidate.  Global participation -- by both the research and ISP communities is desirable.

VI. Mosaic Group Framework Dimension Values

The Mosaic Group, http://mosaic.unomaha.edu/gdi.html, has developed a framework for characterizing the state of the Internet in a nation. They consider six dimensions, each of which has five ordinal values ranging from zero (non-existent) to four (highly developed). The dimensions are as follow:

- pervasiveness: a measure based on users per capita and the degree to which non-technicians are using the Internet.
- geographic dispersion: a measure of the concentration of the Internet within a nation, from none or a single city to nationwide availability.
- sectoral absorption: a measure of the degree of utilization of the Internet in the education, commercial, health care and public sectors.
- connectivity infrastructure: a measure based on international and intranational backbone bandwidth, exchange points, and last-mile access methods.
- organizational infrastructure: a measure based on the state of the ISP industry and market conditions.
- sophistication of use: a measure characterizing usage from conventional to highly sophisticated and driving innovation.

The framework had not been devised at the time of our study of Singapore, so we did not use it in shaping our observations. However, to establish a baseline measure, we have retrospectively assigned the following values as of the time of our study:

| Dimension | Value | |
|---|---|---|
| Pervasiveness | 4 | |
| Geographic Dispersion | 4 | |
| Sectoral Absorption | 3 | |
| Connectivity Infrastructure | 3 | |

| | | |
|---|---|---|
| Organizational Infrastructure | 2 | |
| Sophistication of Use | 2 | |

**The Internet in Singapore**

Pervasiveness

Sophistication of Use — Geographic Dispersion

Organizational Infrastructure — Sectoral Absorption

Connectivity Infrastructure
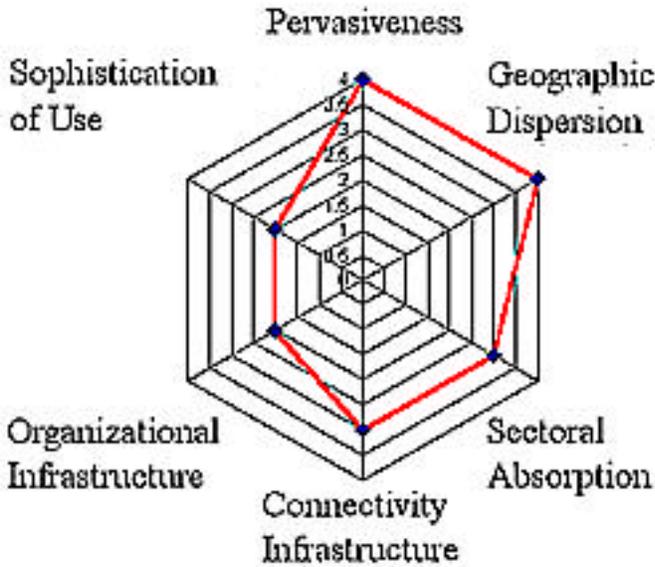
Pervasiveness is rated as level 4, *pervasive*. Singapore has approximately 220,000 dial up accounts and 900 leased line and ISDN accounts. If we assume the switched and leased accounts may have multiple users, and consider public access facilities, it seems reasonable to estimate the number of users at approximately 10% of the population.

Geographic Dispersion is rated at level 4, *nationwide*. Singapore is a special case in that it is a very small nation. Switched analog, ISDN and leased lines are available everywhere. It is expected that DSL and CATV service will soon be available to all apartment dwellers, which comprise roughly 93% of the population.

Sectoral Absorption is rated at level 3, *common*. The ranking is a function of the level of connectivity server ownership in business, government, health care and education. We rated the utilization by business, education and health care as moderate and that of government as common, giving a level 3 rating. The completion of planned education sector plans or progress in any of the other sectors will increase this to 4.

Connectivity infrastructure is rated level 3, *broad*. The high speed ATM ring connecting the ISPs exceeds the 200 Mbps level necessary for level 3 as does the international bandwidth in excess of 70 Mbps. Leased lines are also widely

available.  The only level 2 characteristic is the existence of only one Internet Exchange.

Organizational infrastructure is rated level 2, *controlled*.  There are only three ISPs in the country, and entry and content are regulated by the government.   International connectivity and domestic infrastructure are also monopolistic.

Sophistication of Use is at level 2, *conventional.*  Web browsing is commonly used to find information, but the information served is typically static.  Email is also commonly used as a substitute for other forms of communication, but is not being used in fundamentally novel ways.