

Singapore

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Overview

Singapore is a city-state situated in Southeast Asia, at the southern tip of the Malay Peninsula, occupying approximately 682 square kilometres of land and with a total population of about 4.13 million people (of which 3.32 million are local residents). The country is located between latitudes 1°09'N and 1°29'N and longitudes 103°36'E and 104°25'E approximately 137 kilometres north of the Equator. The main island is about 42 kilometres from east to west and 23 kilometres from north to south, and with coastline of approximately 150.5 kilometres long (Singapore Infomap, 2002).

Singapore gained its independence in 1965, and it has over the years grown to be a business and financial centre in Southeast Asia. Its key economic sectors are manufacturing, construction, utilities, wholesale and retail trade, hotels and restaurants, transport and communications, financial services and business services. Singapore's GDP was S\$153 billion in 2001, with a per-capita GDP of S\$37,145 (SingStat, 2002a). The average exchange rate for the Singapore Dollar per US dollar was 1.72 in 2000 and 1.79 in 2001 (SingStat, 2002b).

Of the local residents, 76.8 percent are ethnically Chinese, 13.9 percent Malay and 7.9 percent Indian. The religious beliefs in Singapore are similarly diverse, and they include 51 percent Buddhism/Taoism, 14.9 percent Islam, 14.6 percent Christianity and 4 percent Hinduism (SingStat, 2000a). The literacy rate is 93.2 percent (SingStat, 2002c).

In the realm of ICTs, 66 percent of the population are conversant in the use of PCs (IDA, 2001a), with 61 percent of households having at least one computer (IDA, 2001c) and about 50 percent of homes having Internet access (IDA, 2001b). All public schools have broadband access, and there are 7,000 public broadband access points located throughout Singapore (IDA, 2001a). The national communications infrastructure has 99 percent island-wide broadband coverage available for access, through ADSL, cable, fibre optic and wireless connections (IDA, 2001a). Telephones are found in 97 percent of households (Ministry of Trade and Industry, 2002). Mobile phones are used by 74.7 percent of the population, while 48 percent of the population are dial-up Internet users (IDA, 2002a). The local scene for the open source movement is developing, with the primary development occurring in educational institutions, supported by some industry efforts.

With regard to the profile of users, 47 percent of the population are computer users (or 55 percent of the population aged 15 and above), with 59 percent of the users using computers both at home and elsewhere, such as work or school. The average number of computer users per household is 2.4, with 16.2 percent of households having four or more users. Among home computer users, 53.4 percent are male and 46.6 percent female. By age group, 5.1 percent of home computer users are 50 years and above, 13.4 percent are 40–49 years, 20.1 percent are 30–39 years, 22.0 percent are 20–29 years, 13.2 percent are 15–19 years and 26.2 percent are below 15 years (IDA, 2001c).

By comparison, 33 percent of the population are Internet users (or 42 percent of the population aged 15 and above), with 54 percent of the users accessing the Internet both from home and elsewhere. The average number of home Internet users is 2.2, with 11.3 percent of households having four or more Internet users. Among home Internet users, 53 percent are male, and 47 percent female. By age group, 4.9 percent of home Internet users are 50 years and above, 12.5 percent are 40–49 years, 21.3 percent are 30–39 years, 26.3 percent are 20–29 years, 15.6 percent are 15–19 years and 19.4 percent are below 15 years (IDA, 2001c).

In terms of Internet usage, 91.6 percent of users aged 15 years and above use it for e-mail and chat, 74.6 percent for information retrieval, 40.3 percent for web applications and 39.8 percent for news or webcast. Among the users, 81.1 percent are aware of online shopping, but only 16.2 percent of the users actually use it (IDA, 2001c).

Content

Singapore is a multiracial and multicultural society. The official languages are English (language of administration), Chinese (Mandarin), Malay (national language) and Tamil, with English emerging as the *lingua franca* of the resident population. English is also the language of instruction in most educational institutions. Various Chinese dialects are also in use, although Mandarin is the common language of use across dialects when English is not used. Among the population, 56 percent are conversant in two or more languages (SingStat, 2000b). Singaporeans' unique version of English has been described as "Singlish", which is a mixture of English words combined with Chinese, Malay and other words.

Media industry

The Singapore media industry is evolving with increasing competition being introduced into the market. Newspapers have previously been dominated by Singapore Press Holdings (SPH),¹ while broadcasting services by Media Corporation of Singapore (MediaCorp).² Today, SPH has entered into broadcasting, while MediaCorp publishes a newspaper. There are also numerous other foreign players in the Singapore media scene. Singapore aims to establish itself as the broadcasting and production hub of the Asia-Pacific region, providing a host of broadcasting and production activities with the capabilities to serve the region and the rest of the world.

Print media

Of the local newspapers, there are currently six in English (*Straits Times*,³ *Business Times*,⁴ *The New Paper*,⁵ *Streets*⁶ and *Today*⁷), three in Chinese (*Lianhe Zaobao*,⁸ *Lianhe Wanbao* and *Shin Min Daily News*), one in Malay (*Berita Harian*⁹) and one in Tamil (*Tamil Murasu*¹⁰) (MITA, 2002a). The daily newspaper circulation is 384 per 1,000 people (SingStat, 2002d).

There are 72 international news agencies, and broadcasting stations¹¹ from Japan, the USA, Germany and other countries based in Singapore. A range of foreign newspapers and magazines¹² are available in Singapore. Publications such as the *Asian Wall Street Journal*, *Asiaweek*, *International Herald Tribune*, *Newsweek*,¹³ *The Economist*¹⁴ and *Time* print and distribute their Asian editions from Singapore (MITA, 2002a).

Broadcast media

There are seven local free-to-air broadcasters (television and radio) in Singapore: MediaCorp TV,¹⁵ MediaCorp News,¹⁶ MediaCorp Radio,¹⁷ SPH MediaWorks,¹⁸ UnionWorks,¹⁹ SAFRA Radio²⁰ and the National Arts Council.²¹ The only foreign free-to-air broadcasting station in Singapore is BBC World Service²² (SBA,²³ 2002a).

MediaCorp also offers an outdoor digital television channel, TVMobile,²⁴ which can be viewed on buses by commuters. MediaCorp News owns and manages ChannelNewsAsia, a dedicated news channel. A second feed, ChannelNewsAsia (International) caters for viewers outside Singapore and serves households in Indonesia, the Philippines, India, Brunei and major hotels in the region. It also has an online arm²⁵ that provides online resources for professionals and executives.

The previous Singapore Cable Vision (now StarHub Cable Vision) (SCV) owns a nationwide broadcast cable network, and it provides a multi-channel cable television service and a broadband Internet service through its network. SCV currently offers about 40 channels and also carries selected cable channels via ultra-high frequency (UHF) and

Singapore facts

Total population:¹³⁹ 4,131,200¹⁴⁰

Total residents: 3,319,100¹⁴¹

Key economic sectors: Manufacturing, construction, utilities, wholesale and retail trade, hotels and restaurants, transport and communications, financial services, business services¹⁴²

Literacy in the national language(s): 93.2%¹⁴³

Literacy in English: 71% (2000)¹⁴⁴

Computer ownership per 100 inhabitants: 47.0 (2000)¹⁴⁵

Telephone lines per 100 inhabitants: 47 (2002)¹⁴⁶

Internet hosts per 10,000 inhabitants: 82.3 (2002)¹⁴⁷

Internet subscribers per 100 inhabitants: 48 (2002)¹⁴⁸

Cell phone subscribers per 100 inhabitants: 74.7 (2002)¹⁴⁹

Number of websites in English and other languages: 339,878 (2002)¹⁵⁰

National bandwidth to and from the country: 21 Tbps submarine capacity and direct Internet connectivity to over 30 countries,¹⁵¹ 2,249 Mbps international Internet connectivity¹⁵²

Sources:

See Notes.

a multi-point, multi-channel distribution system (MMDS) (MITA, 2001). With the cable company's merger with the telecommunications provider StarHub,²⁶ the merged entity started to provide digital telephony services through its cable network from December 2002 (StarHub, 2002a). Rediffusion²⁷ operates a commercial audio broadcasting service over cable in English and Mandarin. It also launched a digital audio broadcasting service in 2000 (Rediffusion, 2000).

There are a variety of foreign television and broadcasting stations²⁸ in Singapore (MITA, 2001) and 15 satellite broadcasters²⁹ licensed to uplink their services from Singapore. Production and post-production companies³⁰ have also established operations in Singapore (SBA, 2002a).

Libraries

The National Library Board (NLB)³¹ is responsible for providing a network of libraries that are convenient, accessible and useful to local residents. NLB operates two regional libraries, 18 community libraries and 43 community children's libraries. Nine of the community libraries are

located in shopping malls. Apart from a collection of more than seven million books and periodicals, the libraries also offer other resources in the form of audiovisual materials and IT resources such as multimedia and online learning resources to the general public. NLB also offers a wide range of online services for the public to access its resources. (NLB, 2003)

Content consumed

With the exception of Internet content (where the source is worldwide), the primary content consumed in Singapore is what the local print and broadcast media deliver to the public. Both MediaCorp and MediaWorks produce their own local content, which supplements other content acquired from foreign sources. In 1999, over MediaCorp's most popular English channel, TCS 5, 46 hours per week (27.4 percent) of transmission are produced locally, while 122 hours (72.6 percent) are acquired from foreign sources, primarily from the USA and Europe. Over MediaCorp's most popular Mandarin channel, TCS 8, 77.2 hours per week (46 percent) of transmission are produced locally, while 90.8 hours (54 percent) are acquired from foreign sources, primarily from around Asia (MITA, 2000). The categories of programmes in broadcast television include news, current affairs, educational, variety, drama and sitcom, children, home shopping and trailers.

Of the programmes offered on cable television, there are 20 English, 9 Chinese (one of which has Japanese programmes dubbed with Chinese subtitles), one Malay and two Indian (Tamil/Hindi) channels, and one channel each of Cantonese, Japanese (separate from the one with dubbed Chinese subtitles), German and French (SCV, 2002).

In the area of films, the average resident watches an average of five movies per year. In 2000, there were 12 cinema operators in Singapore, running 186 cinema halls with a total seating capacity of about 56,000. Most films are imported from foreign sources. In 1999, 74 films were imported from Hong Kong, 9 from Taiwan, 5 from China, 68 from various parts of ASEAN,³² 145 from India, 336 from the USA, 42 from the UK, 43 from Japan and 364 from other sources, amounting to a total of 1,086 imported films (MITA, 2000).

Important national sources of content

AsiaOne <<http://www.asia1.com.sg>>

The AsiaOne is operated by SPH, which also publishes the major local newspapers and operates the broadcasting channels Channel U and Channel i. This website provides news highlights and links to the individual websites of its publications,³³ where electronic versions of the print editions can be found. In particular, the *Computer Times*, a weekly publication distributed with the *Straits Times*, provides up-to-date news, trends and product information relating to the ICT scene in Singapore, catering both to the layperson and

the ICT-savvy. In addition to providing news, AsiaOne also provides a range of lifestyle, business, financial, community and other services. The content is primarily in English, except for the newspapers in their respective languages.

ChannelNewsAsia <<http://www.channelnewsasia.com>>

This website is operated by MediaCorp News, which also runs the broadcasting channel ChannelNewsAsia. The website provides up-to-the-minute coverage of local, regional and international news on topics ranging from politics, finance, business and technology to sports and entertainment. The content is in English.

DBS Bank <<http://www.dbs.com.sg>>

This website is operated by the local bank that has the largest number of domestic customers, the Development Bank of Singapore (DBS). The website provides access to DBS' Internet banking services and allows its customers to perform various types of financial and banking transactions online. The content is in English.

eCitizen <<http://www.ecitizen.gov.sg>>

eCitizen offers a new way through which the public interacts with government agencies. It is a first stop for government services on the Internet and is organised with the needs of citizens and customers in mind. It allows users to search for a diverse range of services from various government agencies and provides access to a wide range of online transactions. The content is in English.

Internet Yellow Pages <<http://www.yellowpages.com.sg>>

This website allows users to search for a wide range of products and services. Searches are available on specific categories, such as automotive, computing, food and beverages, health and recreation, home and office, real estate and travel. It also allows searches on the residential, business and government telephone directory listings, as well as searches for location maps and amenities.

Singapore Government Online Portal

<<http://www.gov.sg>>

This is the focal website of the Singapore government. It is a starting point to find any government-related information. Links are provided to the websites of the individual ministries, statutory boards and organs of state in Singapore. Links are also provided to available government e-services and directories. The content is primarily in English, with some information available in the other official languages.

Singapore Infomap <<http://www.sg>>

Singapore Infomap for Kids <<http://www.sg/kids>>

The Singapore Infomap offers various types of general information on Singapore. It also offers a search facility for websites in Singapore. The Singapore Infomap for Kids contains various types of information regarding Singapore oriented for children. The content is in English.

Singapore Maps <<http://www.streetdirectory.com>>

Can.com.sg <<http://www.can.com.sg>>

These two websites from different providers offer location and map information, including features for locating specific addresses or landmarks. One of the sites offer a service to direct a person from one location to another by driving, walking or public buses. The map features allow a user to pan, scroll and zoom into various parts of the country. The content is in English.

Singapore News <<http://www.sgnews.gov.sg>>

SPRInter: Singapore Press Releases on the Internet <<http://www.gov.sg/sprinter>>

These two websites together provide information on government press releases, announcements, speeches by government ministers and a daily summary of press releases and speeches. Often, the full text of policy announcements can be found here. The content is in English and Chinese.

Yahoo! Singapore <<http://www.yahoo.com.sg>>

This local Yahoo portal offers a search engine for local sites, local content, information and free e-mail services. It also provides links and access to Yahoo's international resources. The content is in English.

Online services

Since the mid-1990s, Singapore has been actively promoting online services in the public, private and people sectors. Today, online services are available in a wide range of areas. The ready availability of computing resources and network access points throughout the country has led to an increase in usage of these services over the years.

E-government

Through the e-Government Action Plan and the eCitizen portal, a wide range of services are now available to the public. These include services in the areas of arts and heritage,³⁴ business,³⁵ defence,³⁶ education,³⁷ elections,³⁸ employment,³⁹ family,⁴⁰ health,⁴¹ housing,⁴² law,⁴³ library,⁴⁴ recreation,⁴⁵ safety and security,⁴⁶ sports,⁴⁷ transport⁴⁸ and travel.⁴⁹ (MOF, 2002).

As of October 2002, there were about 1,625 public services available online, representing about 83 percent of all government services that are considered feasible for e-delivery (IDA, 2002r). It has also been reported that a third of Singaporeans deal with the government through the Internet (ChannelNewsAsia, 2002). The most popular services are:

- enquiry on transacted resale prices of public housing
- search for transacted prices of private residential properties
- enquiry on vehicle-related transactions and rebates
- notification of overseas trips for military personnel
- booking date for military fitness tests

- e-filing income tax returns
- request for Central Provident Fund statements
- checking library accounts

These services collectively amount to about 400,000 transactions a month (IDA, 2002i). The eCitizen portal averages about 4.2 million hits per month (IDA, 2002s).

The income tax e-filing service is one particularly successful service. Filing online is easy; and some 584,800 taxpayers, or approximately one-third of all taxpayers, filed their tax forms online in 2001, an increase of 61 percent over the previous year (IDA, 2001a). The Singapore Supreme Court is also at the forefront in advocating the use of technology by the legal community. Its courtrooms are equipped with the latest IT and audiovisual equipment, and electronic filings are routinely used for submitting legal documents to courts. Technology is also used to support the creation of intellectual property. The Intellectual Property Office of Singapore⁵⁰ has launched SurfIP,⁵¹ a portal that allows inventors, businesses, lawyers, patent agents and users generally to conduct comprehensive and integrated searches for information on intellectual property registered locally and around the world.

E-learning

A variety of e-learning initiatives are available in Singapore. RosettaNet's E-Learning Centre is an example of an industry-wide e-learning initiative (IDA, 2001a). It caters to the manufacturing and chemical industries, involving more than 500 companies. It defines the business process and data exchange standards for the automation of the supply chain. (IDA, 2000d). Its E-Learning Centre aims to provide a platform for companies to share information and experiences on what is needed to successfully implement RosettaNet. This knowledge exchange on a common platform aims to accelerate the adoption of RosettaNet standards and practices, thereby optimising the global supply chain (IDA, 2001q).

The National University of Singapore (NUS)⁵² has an Integrated Virtual Learning Environment (IVLE)⁵³ that allows its faculty members to supplement their classroom teaching through a courseware management system. The system allows the material to be used by more than 20 universities worldwide as part of a virtual campus platform. NUS has spun off a company called WizLearn⁵⁴ to commercialise IVLE. The Institute of Technical Education⁵⁵ also has an e-Tutor system that links its 13 campuses nationwide (IDA, 2001n). The Nanyang Technological University (NTU)⁵⁶ with Cisco Systems⁵⁷ have established a Cisco Academy Training Centre, an e-learning environment that covers the principles and practice of designing, building and maintaining computer networks (*Business Times*, 2000). The centre has trained 11,000 students from various countries in the region, with 2,000 from Singapore (IDA, 2001k). Singapore Management University (SMU),⁵⁸ Singapore's newest university, is also

well equipped with e-learning and IT resources for the benefit of students. The campus offers a high-speed network to enable access to various multimedia applications. SMUConnect is part of the university's e-learning initiative that integrates IT into its curriculum by providing a teaching and learning portal that allows faculty and students to interact online, with course outlines, class lists, project profiles, quiz management, channels and discussion forums specific to courses. Through collaboration with Intel, Intel Lab@SMU provides students with an opportunity to host their own dotcoms on the Internet (SMU, 2002).

E-commerce and e-business

The Internet has become an integral part of the business strategies of companies in Singapore, both for traditional "brick-and-mortar" companies and new-generation and new-economy companies. This is despite the fallout from the bursting of the dotcom bubble. Companies continue to see the importance of embracing an approach that integrates e-business and e-commerce strategies, and transform the way their business is done.

A survey has indicated that B2B sales have increased from S\$40 billion in 1999 to approximately S\$92 billion in 2000. E-procurement has risen from S\$10.9 billion in 1999 to S\$17.9 billion in 2000. B2C activity has also risen, from S\$36 million in 1998 to S\$200 million in 1999 and S\$1.17 billion in 2000 (IDA, 2001).

It has been reported that Singapore's e-business application software market is likely to be worth S\$201 million in 2002, up 25 percent from the year before. The e-business market is expected to enter into high growth in the next two to three years, and by 2005 revenues are expected to double (*Computerworld*, 2002).

Telemedicine

The Singapore General Hospital (SGH)⁵⁹ Postgraduate Medical Institute has an active Telemedicine Continuing Medical Education Programme. The services it provides include (SGH, 2002a):

- monthly teleconferences covering a range of specialties with Stanford University Hospital; University of California, San Francisco; Makati Medical Centre, Manila; and the Chinese University of Hong Kong
- annual hand surgery teleconferences with Mayo Clinic
- neurosurgery teleconferences with the Chinese University of Hong Kong at least once a year
- telesurgery conferences on stapled haemorrhoidectomy

The institute also organises teleconferences in areas such as:

- damage control surgery for severe trauma
- intrapartum management of twin pregnancy
- management of lung cancer
- radiology of breast tumours
- care of HIV patients

The lecture rooms at the institute are equipped with the latest audiovisual equipment and telemedicine capabilities. An educational resource centre is also available to the hospital's employees, and providing library, medical photography and medical illustration services (SGH, 2002b).

Other more experimental telemedicine efforts include projects at Temasek Polytechnic to study issues relating to the transmission of medical images via satellite bandwidth. A project in collaboration with NTU involves the transmission of medical images via the polytechnic's VSAT satellite infrastructure, and a Virtual Training Environment project provides basic knowledge for developing nurses' skills (Temasek Polytechnic, 2002). Another project called Virtual Orthopaedic Surgery Training, a collaborative effort between SGH, NTU, the Moscow Institute of Physics and Technology and the Institute of Computing for Physics and Technology Russia, uses computer tools and virtual reality to let surgeons learn how to fix fractured bones and do preoperative planning without wasting expensive synthetic bones (Sourina, 2000).

E-conference

Singapore's small size limits the application of and demand for e-conferencing within the country. There are, however, pockets of innovation in this area.

During the *Asian Wall Street Journal's* Singapore CEO Tech Summit in 2001, one highlight was a live webcast teleconference involving Singapore's Senior Minister Lee Kuan Yew and former US Secretary of State James Baker in a dialogue on the benefits and implications of technology developments, while the two speakers were physically in Singapore and the USA, respectively (IDA, 2001o). Webcast technology is also regularly used for significant events such as the National Day Parade, allowing Singapore citizens around the world to tune in to the event even when they are not in the country. Occasionally, organisations also use similar technology for broadcasting press conferences and other significant events, or to communicate with staff stationed at multiple locations simultaneously.

E-community

Some innovative and practical examples demonstrating the pervasiveness and penetration of ICTs in the community include a new neighbourhood department store equipping sales staff with handheld wireless point-of-sales terminal to allow them to accept payments from customers anywhere in the store, thus avoiding long queues. Another example is that of taxi drivers going online to look for relief drivers who fit their schedules and who live nearby. Senior citizens can use the Internet as a tool to access health tips and play *mahjong* with friends online. Parents use the Internet and e-mail to keep in touch, and even chat online, with their children who are studying overseas (IDA, 2002o).

In recognition of its enthusiastic push towards an e-lifestyle for its residents Singapore was awarded by the World Information Technology and Services Alliance for Excellence in the Public Sector in June 2000 (IDA, 2000c). An annual e-Celebrations event is held in conjunction with companies, the media and various other organisations and communities to raise awareness and adoption of ICTs among the people. Through such events, the public gets more familiar with using the Internet for e-transactions, e-learning, e-entertainment and e-communication (IDA, 2001d). A National IT Literacy Programme is in place to provide fun and easy training for the masses in IT through 30 authorised training centres. The programme has the objective of helping 350,000 residents, especially workers, homemakers and senior citizens, learn basic things about using computers and the Internet (IDA, 2001e). After one year, about 100,000 residents have been trained. In September 2002, an Infocomm Literacy Month was launched with the Great Singapore Surf, the biggest mass IT training event ever held in Singapore that aimed to, over two days, equip 10,000 residents with ICT literacy skills (IDA, 2002o).

ICT industries and services

The ICT sector in Singapore includes both local and multinational companies. A survey in 2001 found that the total Singapore ICT industry had a market value of approximately S\$26 billion (including products and services, but excluding ICT-related manufacturing activities). Exports made up 48.4 percent of the overall ICT revenue in 2000, while the domestic market was valued at S\$13.4 billion. In the overall ICT market, hardware has the largest share (38 percent), followed by telecom-munications (35 percent), IT services (14 percent) and software (11 percent). The remaining 2 percent is represented by online digital media and others. In the domestic market, revenue contributions comprise 48 percent from telecommunications, 20 percent from hardware, 12 percent from software, 17 percent from IT services and 1 percent from online digital media. In the export market, the contributions are 57 percent from hardware, followed by 21 percent from telecommunications, 11 percent from IT services and ten percent from software (IDA, 2001f).

The telecommunications services sector in Singapore was completely liberalised in April 2000. Since then, many players with global names have entered the local market, offering a wide range of services. As of October 2002, there were 33 facilities-based operator licensees and 631 services-based operator licensees (IDA, 2002b). Through a network of submarine cables and direct Internet connections to over 30 countries, Singapore has also become one of the most connected cities in the world, reaching to all of Asia, the Middle East, Europe and the USA. There is more than 45 Mbps direct Internet connectivity to each of Asia's key markets (IDA, 2001a). Singapore has an extensive submarine

cable network with a total capacity of 21 Tbps⁶⁰ comprising pan-Asian cables, including Asia Pacific Cable Network 2 (APCN2) (2.56 Tbps), C2C Cable Network (7.5 Tbps), East Asia Crossing 2 (EAC2) (2.56 Tbps), Network i2i (8.4 Tbps) and Nava (IDA, 2002c). Domestically, broadband services are available today through modes such as ADSL, cable, fibre optic and wireless. New broadband access in the area of powerline communication is also being tested.

The local ICT industry has historically been focused on manufacturing. Such manufacturing-based companies may face more threats in the form of competition from regional countries on the basis of the cost of manufacturing. As manufacturing is primarily export-based, fluctuations in the regional and global economy also have a direct impact on these companies. Increasingly, companies in the ICT services sector are expected to gain greater prominence over manufacturing-based ones. The traditional manufacturing-based companies may also move into higher value-added areas of expertise and other services to survive.

There are new and emerging opportunities in Asia. The region is a diverse market and various parts of Asia have grown in strength in different aspects of ICTs. This diversity is an opportunity as each country, state or city can offer a different market proposition based on its strength and they can complement each other. The Asian market comprises more than half of the world's population and has a younger workforce than in the USA and Europe. The Asian middle class is also expanding and consuming more ICT goods and services. The need for telecom-munications services is likely to continue to grow as Asia continues to have increasing demand for such services. However, there are challenges that need to be addressed, such as the alignment of policies and standards and the opening up of markets in various countries. Effective coordination across governments and industry is needed to deal with the issues (IDA, 2002k).

Significant ICT companies in Singapore⁶¹

Chartered Semiconductor Manufacturing Limited

<<http://www.charteredsemi.com>>

Chartered Semiconductor Manufacturing is one of the world's top three silicon foundries. The company provides manufacturing solutions for customers, enabling the convergence of communications, computing and consumer applications. It has five fabrication facilities in Singapore, and a sixth facility is being developed. The company is traded on NASDAQ and the Singapore Exchange. It has 4,000 employees based at 12 locations around the world. It has announced a joint agreement with the Interuniversity MicroElectronics Center,⁶² Europe's largest independent R&D centre in the field of microelectronics, nanotechnology, enabling design methods and technologies for ICT systems. This is expected to result in the company offering new manufacturing capabilities by the second half of 2003.

Creative Technology Limited <<http://www.creative.com>>
Creative Technology is a global leader in PC entertainment products, focusing on providing solutions that give a new way to experience games, music and entertainment on the desktop. Founded in Singapore in July 1981, the company is best known for its award-winning Sound Blaster line of audio cards. Since then, it has built on the popularity and demand of its PC audio success to roll out new products in the areas of graphics, DVD, computer telephony integration, communications, videoconferencing, personal digital entertainment solutions, desktop products, Internet appliances and Internet applications and services.

Datacraft Asia Limited <<http://www.datacraft-asia.com>>
Datacraft is a network and e-business systems integrator in Asia Pacific, specialising in building and managing integrated intelligent infrastructure and providing applications that enable businesses to work together seamlessly, both internally and externally. It is listed on the Singapore Exchange since 1995. In 1997, Dimension Data Group, listed on the London Stock Exchange, acquired a major shareholding in the company. The company has established more than 60 offices located throughout China, Hong Kong, India, Indonesia, Japan, South Korea, Malaysia, Taiwan, Thailand, Singapore, the Philippines, New Zealand and Vietnam. It has more than 1,600 staff, with distributed headquarters in Singapore and Hong Kong.

ECnet Limited <<http://www.ecnet.com>>
ECnet is a global provider of collaborative supply chain solutions and management services. It helps organisations to rapidly integrate and streamline their business processes and optimise collaborative commerce activities with multiple business partners. The company was founded in Singapore in 1995, with domain expertise in collaborative supply chain solutions in nine countries and territories in the Asian market. It is headquartered in Singapore. Its investors include Goldman Sachs, Morgan Stanley, Doll Capital, 3i, AsiaTech and SilkRoute Holdings.

ECS Holdings Limited <<http://www.ecssin.com.sg>>
ECS Holdings is the holding company of a group of four companies comprising ECS Computers (Asia) Private Limited in Singapore, ECS KUSH Sdn Bhd in Malaysia, the Value Systems Co. Limited in Thailand and PCI-SLR Technology (China) Limited in China. It is listed on the Singapore Exchange. The company was first established as an IT product distribution company. Today, it is an IT solutions provider, with competencies in the areas of e-infrastructure, e-services and e-distribution.

Flextronics International Singapore Private Limited <<http://www.flextronics.com>>
Flextronics is an electronics manufacturing services provider focused on delivering operational services to technology companies. It is headquartered in Singapore, with

approximately 70,000 employees. The company has design, engineering, manufacturing and logistics operations in 28 countries and 4 continents. Its global presence provides its customers with the resources, technology and capacity to optimise their operations. The company provides end-to-end operational services that include innovative product design, test solutions, manufacturing, IT expertise and logistics.

HP Singapore <<http://thenew.hp.com/country/sg/eng/welcome.html>>
Hewlett-Packard (HP) is a technology solutions provider for consumers and businesses, with market leadership in fault-tolerant servers, UNIX servers, Linux servers, Windows servers, storage solutions, management software, imaging and printing, and PCs. It employs 65,000 professionals worldwide. Singapore is one of the largest and most diverse sites for HP outside of the USA. HP Singapore has nearly 5,000 employees spread over eight locations, including four manufacturing sites. Besides manufacturing for customers worldwide, HP Singapore is responsible for Singapore, Southeast Asia and Asia-Pacific sales. It also conducts R&D and provides marketing activities, customer support and infrastructure services for the Asia-Pacific region.

Hitachi Asia Limited <<http://www.has.hitachi.com.sg>>
Hitachi Asia is a wholly owned subsidiary of Hitachi Ltd in Japan. It was established in Singapore in 1989 as one of the four regional headquarters for Hitachi's worldwide operations. It employs more than 800 people in 20 offices across 10 countries and is responsible for Hitachi's sales and marketing operations throughout Asia, excluding Japan. It is also responsible for international procurement of materials and components and manages the financial activities of the Hitachi Group with selected in-house banking services. Its products and services include semiconductors, electronic tubes, elevators and escalators, air-conditioning and refrigerating equipment, plant and industrial machinery, and application system solutions.

IBM Singapore <<http://www.ibm.com/sg>>
In 1953, IBM established a branch office in Singapore to market and service its data processing equipment. Its Singapore office, which houses the Singapore team and its regional team for Asia, has since grown to 4,500 staff. IBM offers a range of integrated solutions, products and services. IBM Singapore has played a significant role in the use and development of IT in Singapore. It is actively involved in projects led by the government, such as in the promotion of IT in schools.

IPC Corporation Limited <<http://www.ipc.com.sg>>
IPC Corporation is an IT vendor providing thin computing, e-services, e-platform, information and communication products, and broadband systems integration solutions. The company is listed on the Singapore Exchange and operates in Singapore, China, Hong Kong, the USA and the UK. Its

core business was previously in computers and peripherals. This ceased in 1998 and the company moved into its present business in ultra-thin client technology, telecommunications and e-services.

Keppel Telecommunications and Transportation Limited
<<http://www.keppeltt.com.sg>>

This is a member of the Keppel Group of companies. It is headquartered in Singapore and has operations across Asia, North America and Europe. The company has its roots in the Straits Steamship Company Limited incorporated in 1890. Today, the company provides businesses in Asia with logistics, telecommunications and enabling services. Under telecommunications, it offers mobile communications services and network engineering and technology solutions. Under e-business, it offers network security, Internet hosting and IT services. The company is one of the main shareholders (with 35 percent share) of the second mobile telecommunications service provider in Singapore, MobileOne.

Matsushita Electric Asia Private Limited
<<http://www.panasonic.com.sg>>

Matsushita Electric Asia is a regional company based in Singapore under the Matsushita Electric Industrial Group.⁶³ Its principal activities are exporting, importing and selling of Matsushita's electrical and electronic products, ranging from electronic components to consumer electronic products, home appliances, factory automation equipment, information and communications equipment, and household products. The products are marketed under the brand names of National, Panasonic and Technics.

Microsoft Singapore

<<http://www.microsoft.com/singapore/welcome.asp>>

Microsoft Singapore was established in 1990. It has made significant inroads in its .Net services through the .Net MySingapore partnership with the government and has also established Microsoft's XML Web Services Centre in Singapore. .Net MySingapore provides a range of community-oriented web services to save people time and take the hassle out of many daily tasks, such as booking a taxi, enrolling in a course, searching for a job, or even organising dinner with friends. Other innovative services that the company has delivered include providing a mobile version of its Hotmail services to mobile phone subscribers in Asia in conjunction with SingTel Mobile in Singapore, CSL in Hong Kong and ChungHwa in Taiwan. Microsoft has also provided technology to enable Movie Magix, a video-on-demand service provided in conjunction with SingTel. The service allows the latest movies to be watched from home PCs over an ADSL broadband network. Microsoft is also working with network service providers to nurture a developer community and encourage the creation of wireless applications targeting both consumers and corporate users.

Motorola Electronics Private Limited

<<http://www.motorola.com.sg>>

Motorola was established in Singapore in 1983, although it first began its distribution operations here in 1973. Today, Motorola in Singapore has about 2,000 staff in manufacturing, R&D, marketing, sales, distribution and support. Singapore is the operational headquarters and coordinates and supports its regional subsidiaries.

National Computer Systems Private Limited

<<http://www.ncs.com.sg>>

National Computer Systems (NCS) is an IT service provider. It was previously the IT arm of the then National Computer Board. It was corporatised in 1996 and in 1997 became a part of the SingTel Group. It currently has 2,800 staff and has one of the largest teams of IT expertise in the region. The company's main products and services are in the areas of e-business consulting, e-solutions, network integration and e-outsourcing services. It services customers in the industries of education, defence, health-care, financial services, public services, telecommunications, transportation and logistics. NCS recently merged with SingTel Aeradio Pte Ltd, with the latter becoming a fully owned subsidiary of NCS. The combined entity makes NCS one of the largest IT and engineering service providers in the region with a total annual revenue of S\$600 million.

Nera Telecommunications Limited

<<http://www.neratel.com.sg>>

Nera Telecommunications offers a comprehensive mix of products and services ranging from satellite communications and microwave radio transmission to IT, networking infrastructure and high-end electronics contract manufacturing. It services the markets of Singapore, Malaysia, Thailand, Indonesia, the Philippines, Vietnam, Brunei, Laos, Cambodia, Myanmar, Taiwan and South Korea through its headquarters in Singapore. The company primarily engages in the sales, distribution and servicing of the Nera brand of satellite communications and transmission products. It also provides sales, installation, maintenance and servicing of IT networks, as well as contract manufacturing for the telecommunications, professional electronics and health-care industries.

SilkRoute Holdings Private Limited

<<http://www.silkroute.com>>

SilkRoute was founded in 1994 and was the first Internet company in Singapore. The company has evolved into a network of e-commerce companies with a growing Asian presence. It develops and manages B2B e-commerce businesses, an area where it possesses the know-how and has a proven track record. It also has funding, management and technological expertise, and it has strong alliances with leading technology partners. The company has won several inaugural awards for its innovativeness and leadership in breaking new grounds in the Internet industry. The group

collectively employs about 200 people and has launched several Internet companies funded by SilkRoute Capital. New businesses and services are being developed by SilkRoute Ventures.

Singapore Computer Systems Limited

<<http://www.scs.com.sg>>

Singapore Computer Systems is an ICT service provider in the Asia-Pacific region. It was incorporated in 1980 and is a member of the Singapore Technologies group.⁶⁴ It has 2,000 staff and operates in Singapore and eight other countries – Australia, Brunei, China (including Hong Kong), Malaysia, New Zealand, the Philippines, Thailand and the USA. It provides services in IT and business consultancy, systems integration, outsourcing, networking, e-commerce, product development, design and implementation of systems, business recovery, and call centre services.

Singapore Technologies Assembly Test Services

Limited <<http://www.stts.com>>

This company is a provider of full turnkey semiconductor test and assembly services to companies that do not have production facilities, integrated device manufacturers and wafer foundries worldwide. It offers its customers a range of integrated test and assembly services in communications, networking and PC applications, and it has different testing platforms for various test requirements. It also offers advanced semiconductor packages for wired and wireless communications. The company operates customer support offices in Singapore, the UK, France, Japan, Taiwan and various US locations, including California, Arizona, Texas, Massachusetts and North Carolina.

Singapore Technologies Engineering Limited

<<http://www.stengg.com>>

Singapore Technologies Engineering is an integrated global engineering group with specialised expertise in aerospace, electronics, land defence systems and marine capabilities for defence and commercial enterprises. The group is 10,000 strong and is one of the largest companies, by market capitalisation, on the Singapore Exchange. It is the engineering and defence arm of Singapore Technologies. Its subsidiary, Singapore Technologies Electronics Limited,⁶⁵ is one of the largest systems design and integration companies in the region, delivering proprietary, innovative, customised and turnkey solutions for systems and components.

Singapore Technologies Telemedia Private Limited

<<http://www.sttcomms.com>>

Singapore Technologies Telemedia (ST Telemedia) is an information and communications group in Singapore and the region. It was incorporated in 1994 and has three core businesses in data and voice, broadband and multimedia, and e-services. The company offers fixed and mobile

telecommunications services, wireless data communications services, Internet mobile services, managed network services, managed hosting services, satellite services, and enhanced broadband and multimedia services. It is a wholly owned subsidiary of the Singapore Technologies group. It is the majority shareholder (50.47 percent) of the merged StarHub and SCV entity (ST Telemedia, 2002). In addition, the company, with Hong Kong's Hutchison Whampoa, has entered into a deal to acquire a 61.5 percent stake in the US-based submarine cable operator Global Crossing. It is also expected to acquire a 48 percent stake in the NASDAQ-listed Equinix, a network and IT infrastructure services provider (*Straits Times*, 2002c).

Singapore Telecommunications Limited

<<http://www.singtel.com>>

Singapore Telecommunications (SingTel) is an integrated communications service provider in Asia Pacific with a comprehensive portfolio of services that include voice and data services over fixed, wireless and Internet platforms. The company serves both corporate and residential markets in Asia Pacific and beyond. It has two main hubs (in Singapore and Australia), which are complemented by a significant presence in rapidly growing markets in Asia through investments in Hong Kong, India, Indonesia, the Philippines, Taiwan and Thailand. It offers a wide range of communications services in Singapore and Australia, such as national and international telephone services, mobile communications services, and public data and private network services.

StarHub Private Limited <<http://www.starhub.com.sg>>

StarHub is Singapore's second fixed-line public telecommunications service provider. It merged with the local cable television and broadband service provider in 2002, and it presently offers a full range of information, communications and entertainment services over fixed, mobile and Internet platforms. The company, through SCV, owns a nationwide broadband network that delivers multi-channel pay-TV services as well as data, voice and Internet access services. It also operates its own mobile cellular network.

Teledata (Singapore) Limited

<<http://www.teledata.com.sg>>

Teledata's principal activities are in systems integration and specialised distribution of voice, video and data communication products and services. It was one of the pioneers in the IT and telecommunications sector since 1976. The company has a presence in Brunei, China, Hong Kong, India, Indonesia, Israel, Japan, South Korea, Malaysia, Myanmar, Pakistan, the Philippines, Thailand and Vietnam, and it has over 400 employees. It is listed on the Singapore Exchange.

Venture Corporation Limited

<<http://www.venture-mfg.com.sg>>

Venture Corporation (formerly known as Venture Manufacturing) is a global electronics service provider. Founded in 1984, it comprises 23 companies with operations in Asia, North America and Europe. The company is listed on the Singapore Exchange. It has strong engineering expertise and is the strategic partner for long-term manufacturing for top Fortune 500 companies, including Agilent, Cisco, HP, IBM and Motorola. It provides a full spectrum of high value-added integrated turnkey manufacturing services comprising complex printed circuit board assemblies, strategic sub-assemblies, complex fibre optics assemblies, full product assemblies, instrumentation products, networking and communications products, handheld computers and portable data terminals, medical devices, systems integration, and complex test development.

- Using infocomm technologies to build new capabilities and capacity
- Innovating with infocomm technologies

The eCitizen portal, discussed earlier, is designed to provide access to services that the public commonly needs to deal with the government. The services are designed around major life events of a citizen, such as family life, housing, education, employment, transport and health. The portal allows the citizen to easily find the services needed without necessarily knowing or understanding which specific government agency is responsible for that function. As of October 2002, there were about 1,625 e-services (IDA, 2002r) organised around 16 towns (MOF, 2002).

The success of the portal has earned eCitizen the bronze award at the Commonwealth Association for Public Administration and Management International Innovation Awards Programme (IDA, 2000e).

Examples of innovative and key initiatives

Infocomm 21 Strategy

The government has a five-year strategic plan called Infocomm 21 that sets out the broad directions and strategic thrusts for the ICT sector (IDA, 2001b). The plan is intended as a strategic framework and guide for the industry and is to be updated periodically with the changing technological, business and social landscape. The government sees its role as catalytic, with the industry taking the lead in the implementation of the strategy and the government focusing on facilitating international alliances and creating an environment that is conducive for businesses to thrive.

The six broad strategic thrusts in Infocomm 21 are:

- Singapore as a premier infocomm hub
- Singapore businesses online
- Singapore government online
- Singaporeans online
- Singapore as infocomm talent capital
- Conducive pro-business and pro-consumer environment

In the plan, each of these thrusts sets out a vision, the desired outcome, and a set of key strategies and initiatives to realise the vision.

E-government

The government, under the purview of the Ministry of Finance (MOF) has a S\$1.5 billion e-Government Action Plan.⁶⁶ The Infocomm Development Authority of Singapore (IDA)⁶⁷ is the technical advisor and manager of the plan. The main thrusts of the plan are (Singapore Government, 2002):

- Reinventing government in the digital economy
- Delivering integrated electronic services
- Being proactive and responsive

E-business and e-commerce

The government's strategy to develop Singapore into a global and trusted e-business hub includes efforts to provide a clear and conducive regulatory environment, lay a robust and secure foundation for e-business, create a trusted e-business environment, and catalyse e-business transformation (IDA, 2001a). Laws for enabling electronic transactions and self-regulatory codes in areas such as data protection are essential components of the policy framework. To make available and to promote a suitable security infrastructure that facilitates the building of trust relationships and the enabling of electronic payment, a Singapore Public Key Infrastructure (PKI) Forum⁶⁸ has been set up in conjunction with the Asia PKI Forum.⁶⁹ The Singapore PKI Forum comprises members from leading local and international companies that are committed to building an environment that enables end-to-end e-commerce and e-business transactions.

The government has in place an Approved Cyber Trader (ACT) scheme, an incentive to cultivate and develop companies that are in e-business or e-commerce. Companies based in Singapore that conduct international business through the Internet can qualify for the ACT incentive, which is a 10 percent concessionary tax. Companies under the scheme are expected to conduct their principal e-commerce activities in Singapore and handle a range of business activities and support functions in Singapore, such as server farms, database management, website content hosting, design and development, general and administrative management, business development and investment planning, financial control and treasury functions, logistics management, centralised distribution function, and R&D of Internet applications and technology (International Enterprise Singapore, 2002).

In addition, the e-Business Industry Development Scheme is available to locally registered companies operating in Singapore. The scheme is targeted at companies with

existing e-commerce capabilities and wish to expand further on their e-business value creation. This scheme is performance-based, where the government funds the companies proportionally based on the total e-commerce value created, which is tied to the actual online transaction value brought about (IDA, 2001g).

Industry development

To develop and promote the broadband industry, the government has an International Content Hosting Scheme (ICHS) and a Content Enrichment Scheme (CES) to enable companies to engage in broadband development. ICHS is intended to attract high-end media-rich content to Singapore, and it gives financial grants to providers to deploy services and jumpstart operations that have large hosting and connectivity requirements (IDA, 2001k). CES is designed to provide grants to enhance the capabilities of broadband developers and the content of service providers by improving existing narrowband applications with broadband content, or by extending existing broadband content to new and emerging platforms such as wireless (IDA, 2001r). A Broadband Media Association⁷⁰ has been formed to enable the industry to play an active leadership role in discussing issues and to develop partnerships and alliances between the members.

For small and medium enterprises (SMEs), there are the Local Enterprise Finance Scheme, a fixed interest rate loan for companies to expand and develop new capabilities (SPRING, 2002a), and the Local Enterprise Technical Assistance Scheme, a consultancy grant scheme to help SMEs acquire new competencies in operational management (SPRING, 2002b).

There is also an Infocomm Local Industry Upgrading Programme that brings local companies together with multinational companies (MNCs) to cultivate stronger ties and collaborations between them. It provides the opportunities for local enterprises to gain exposure to cutting edge technologies and tap on the global network and marketing and distribution expertise of MNCs. The MNCs benefit from the opportunity to adopt their technologies for locally developed products and services and from the local enterprise's vertical domain expertise. The current participating MNCs include Apple, Cisco Systems, Computer Associates, HP, IBM, Microsoft, Oracle and Sun Microsystems (IDA, 2002d).

The government regularly issues calls for collaboration to bring together various players in the industry to innovate in government-funded trials. At least seven calls have been issued so far, including one for mobile payment, involving handset manufacturers, banks and service providers coming together to develop a first-of-its-kind mobile payment infrastructure in Singapore. Collaboration between industry and schools has also enabled the use of broadband for an enhanced teaching and learning experience. Through the facilitation of the government, the calls allow new applications and new services to be developed, and local

companies are linked with international partners for knowledge exchange and transfer. The government also organises seminars to enable companies to network and learn about the latest developments with other players (IDA, 2002e).

The Singapore Infocomm Technology Federation (SITF),⁷¹ an industry-led consortium, has created a Singapore Enterprise Chapter that helps local companies promote and market their products and services locally and internationally. SITF has also taken on efforts in new specialised areas such as wireless, application service providers (ASPs), Internet data centres (IDCs) and e-learning.

In the wireless industry, players in collaboration and partnerships, have used Singapore as a testbed for new services. Through the government's Wired with Wireless Programme, wireless research, trials and pilots can be conducted and commercial services tested and launched (IDA, 2001h). The SITF Wireless Chapter has members with the skills and industry experience to help develop the wireless market and to provide a proactive industry platform to address the challenges and opportunities of the mobile e-economy.

In the area of ASPs, collaborative efforts between industry, government and research institutes have led to the creation of competency centres to develop local competencies and foster innovation. An ASP Alliance Chapter has been established by SITF to promote and develop the ASP market in Singapore.⁷²

Singapore's IDCs have grown to over 20 in number. They provide a range of services from web to ASP hosting, content delivery services, co-location, provision of managed services, security and disaster recovery. The leading IDCs have regional and international points of presence and use Singapore as a gateway to the region (IDA, 2001m).

The first Online Learning Asia Conference was held in Singapore in May 2001. This was one of the fruits of the establishment of SITF's e-Learning Chapter (IDA, 2001n). The e-Learning Chapter acts as the industry voice and represents the industry in discussions with the public sector, the media, user groups and other industry organisations. It facilitates networking and alliance formation, develops benchmarking, upgrades the competency and standards compliance of industry players and creates branding for the Singapore e-learning industry (*Computerworld*, 2001).

Developing manpower and capability

One of the government's key promotional efforts is targeted at developing capabilities. The enhanced Critical Infocomm Technology Resource Programme (CITREP) has upgraded the skills of 3,900 ICT professionals in emerging technology areas such as bioinformatics, Linux and XML (IDA, 2002p). CITREP is a training incentive programme to accelerate the development of emerging, critical and specialised ICT skills required by industry and user organisations. It evaluates and endorses relevant training courses and provides support by

partially funding the cost of attending the courses and taking examinations (IDA, 2002f).

The government also encourages the establishment of competency centres led by key technology companies together with local institutions of higher learning and research institutes to foster technology transfer and develop new capabilities in emerging areas. Under the Wireless Technology Alliance, an initiative with the Wired with Wireless Programme, the Java Wireless Competency Centre was established to promote the development of wireless solutions built on the Java platform (IDA, 2001i). An ASP Competency Centre, a joint effort between the government, the private sector and the education sector, offers incubation services to help the local industry develop ASP services (IDA, 2001p). An e-Learning Competency Centre was also established to drive and promote the adoption of e-learning standards, best practices and professional development (IDA, 2002m).

The government has an Infocomm Training and Attachment (iTA) Scheme that provides opportunities for training with selected organisations in the ICT industry in areas of hot and emerging technologies, thus increasing the available manpower with the skills and expertise needed by the local industry. The scheme provides for local and overseas training and attachment of employees and non-employees (IDA, 2002g). Companies have used the scheme to develop the required expertise for R&D to be undertaken in Singapore.

Enabling policies

National, regional and international initiatives

The Infocomm 21 strategic plan (IDA, 2001b) (described earlier) maps out the national policies for promoting ICTs. This strategic plan is complemented by efforts at boosting collaboration and cooperation at the regional and international levels.

ASEAN comprises ten regional member states – Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. An e-ASEAN Framework Agreement⁷³ is in place to enhance collaboration among these countries to develop a common marketplace for ICT goods and services, facilitate infrastructure investment and develop the infrastructure and policy framework for e-commerce and e-government. The e-ASEAN Task Force⁷⁴ is expected to develop a broad and comprehensive plan to realise the intent of the Framework Agreement. Examples of e-ASEAN initiatives already launched include a legal framework for e-commerce to promote the recognition of digital signature and a Certification Authority Forum to develop common technical standards for the cross-recognition of digital certificates.

Beyond the region, Singapore has also been actively pursuing free trade agreements (FTAs)⁷⁵ with its major trading partners, such as Japan, the USA, Australia, New

Zealand, the European Free Trade Association (representing Switzerland, Norway, Liechtenstein and Iceland), Mexico, Canada and India. These FTAs aim to further improve trade and investments between the countries by lowering tariffs for ICT goods, simplifying customs procedures and improving market access for commercial and professional ICT services.

Policy-making bodies

Lead agencies

Historically, the responsibility for developing sectoral policies in ICTs has been undertaken by separate government agencies. The IT, telecommunications and broadcasting sectors were governed by three sector-specific agencies under the purview of three different ministries:

- IT, including e-commerce, by the then National Computer Board (NCB) under the Ministry of Trade and Industry (MTI).
- Telecommunications, by the then Telecommunication Authority of Singapore (TAS) under the previous Ministry of Communications.
- Broadcasting, by the then Singapore Broadcasting Authority (SBA) under the former Ministry of Information and the Arts. SBA also regulated Internet content issues as Internet is considered a form of broadcasting.

The creation of NCB in 1981 signified the start of a major push by the government in the technological realm. Over its 18-year history, the mission of NCB had evolved from one primarily focused on computerising the government to one that included promoting IT and e-commerce to industry and the masses. NCB was initially under the purview of MOF as the latter was the central ministry responsible for government computerisation. In 1997, NCB was moved from the purview of MOF to MTI, a recognition that IT and e-commerce were key economic sectors to be planned and strategised in conjunction with Singapore's broader economic aspirations.

In the telecommunications services sector, there was initially a national telephone service provider. In 1992, it was split into a regulator, TAS, and a corporatised operator, SingTel. SingTel largely enjoyed a monopoly until 1995, when the telecommunications services market was opened up to allow new players in segments such as paging and cellular services.

In the broadcasting sector, there was also initially a national broadcaster for television and radio. In 1994, the broadcaster was split into a corporatised operator and a regulator. The regulator, SBA, was under the purview of the then Ministry of Information and the Arts. The corporatised operator, Singapore Broadcasting Corporation (SBC), subsequently became the MediaCorp group of companies, under the holding company Media Corporation of Singapore.

In 1999, NCB and TAS were merged to form IDA, under the purview of the then Ministry of Communications and IT (MCIT). IDA undertook the combined responsibility of

regulating and promoting the ICT industry. The then SBA remained unchanged as the agency responsible for regulating broadcasting and Internet content. The creation of IDA is significant in bringing together the oversight of the IT, e-commerce and telecommunications sectors under a single agency. It has also brought together the regulatory and promotional functions for these sectors under the same roof. IDA has an investment arm (Infocomm Investments Pte Ltd) that complements IDA by using equity investments to support IDA's vision and objectives. The investments are focused on companies and projects that bring strategic added value to the ICT industry. However, to avoid any potential conflict of interest, the subsidiary does not invest in any company that requires a licence to be issued by IDA to operate in Singapore.

In 2001, IDA was moved under the purview of an expanded Ministry of Information, Communications and the Arts (MITA)⁷⁶ bringing it under the same supervising ministry as SBA, while MCIT became the Ministry of Transport. This move further provides the ability for many issues related to ICTs, broadcasting and the media to be resolved under the guidance of a single ministry and sets the stage for a more integrated policy approach towards managing the converging ICT, broadcasting and media sectors.

At end 2002, the merger of SBA, the Films and Publications Department of MITA and the Singapore Film Commission brought about the creation of the Media Development Authority (MDA) on 1 January 2003. MDA remains under the purview of MITA and has the charter of developing Singapore into a vibrant global media city by promoting the growth of the media industry, as well as a creative economy and a connected society by managing content to protect core values and safeguard consumers' interests.

Supporting agencies

Supporting the promotional and developmental roles of the above agencies are the agencies under MTI: Economic Development Board (EDB); International Enterprise (IE) Singapore; Agency for Science, Technology and Research (A*STAR); and Standards, Productivity and Innovation Board (SPRING Singapore). These agencies each have promotion roles and, in accordance with their own organisational goals and missions, supplement the efforts of the lead sectoral agencies to align and integrate the promotion of the ICT and broadcasting sectors with other national economic promotional programmes and plans.

MTI⁷⁷ was created out of the former Development Division of MOF in 1979, and it has been tasked with the responsibility of anticipating problems ahead, identifying opportunities for growth, rationalising existing policies and giving broad directions for growth. The ministry has nine statutory boards and one government department under its purview. It consists of divisions in economics, enterprise, resource, trade and international business development.

EDB⁷⁸ was established in 1961 to plan and execute strategies to make Singapore a hub for businesses and investments. It attracts large and major investors to Singapore, and it enables multinational and Singapore-based companies to expand and upgrade to higher value-creating operations across manufacturing and internationally traded services.

IE Singapore⁷⁹ (previously the Trade and Development Board) helps local companies reach the overseas market and become international players. It offers a range of services, both locally and overseas, to help companies shorten their learning curve and make the right connections. These services include providing market information, conducting feasibility studies and finding overseas partners. With the view of promoting Singapore as an SME hub, the agency also attracts enterprises from other countries to be based in Singapore and collaborate with Singapore companies to venture to the region.

A*STAR⁸⁰ (previously the National Science and Technology Board) cultivates local R&D in various sectors. It promotes and encourages science, engineering and biomedical research and nurtures talents. One of its key objectives is to strengthen the scientific knowledge and economic competitiveness of Singapore to develop a foundation of high-quality research. It has funded various large-scale research projects. The agency also promotes the exploitation of intellectual property created by local research institutes; a separate technology transfer and commercialisation arm (Exploit Technologies Pte Ltd) has been established for this purpose.

SPRING Singapore⁸¹ (previously the Productivity and Standards Board) is responsible for raising productivity to enhance the nation's competitiveness and economic growth. Its areas of focus are in productivity and innovation (focusing on promotion, business excellence, people excellence and service excellence), standards and quality (focusing on standardisation, conformity assessment and measurement infrastructure development), and SMEs and the domestic sector (focusing on broad-based enterprise upgrading and industry transformation).

Supporting the development of the ICT legal infrastructure are the Ministry of Law⁸² and the Attorney-General's Chambers.⁸³ These agencies provide the legal perspective to support the establishment of the legal infrastructure for ICT sectors. They are instrumental in working with the lead agencies to put together the legislation that governs the ICT and broadcasting sectors today. In addition, the Intellectual Property Office of Singapore (IPOS) is responsible for providing the infrastructure, platform and environment for the greater creation, protection and exploitation of intellectual property.

Committees

In 1996, the National Internet Advisory Committee (NIAC) was appointed by the then Ministry of Information and the Arts to advise SBA on the regulation of electronic

information services and the development of the Internet industry and to assist in the development of SBA's regulatory framework for the Internet. It also provides feedback and advice on the impact of technological developments and other Internet-related issues. The members of NIAC comprise both private sector and public sector representatives (SBA, 2002b). With the creation of MDA as the successor of SBA, NIAC now advises MDA.

In 1992, the government set up the National IT Committee (NITC) as an advisory platform to NCB to monitor and guide the promotion and use of IT in the various sectors of the economy. With technological convergence and the ability to provide more services in the online environment, there is an increasing need to involve other government agencies in the policy formulation process so that a balance of the competing needs and interests can be reached. In 1997, recognising the need to drive the execution of the national IT plans in different ministries and the need to coordinate cross-agency policy issues relating to online services, the government revamped NITC into a high-level multi-agency policy-making committee with an executive mandate. NITC is represented by top ministerial officials and deals with issues that require building consensus across agencies and ministries. When IDA was created in 1999, NITC became the National Infocomm Committee.

Regulatory environment

The telecommunications services market evolved from a national monopoly operator providing telephone and postal services. Through the government's liberalisation policy, new players were introduced into the market over time, and some parts of the monopoly were broken up into separate business units, each focusing on a certain market segment (e.g. postal, paging, mobile and Internet services). The then telecommunications regulator, TAS, evolved from a background where intervention and restriction were the norm and the licensing framework was largely built on the premise that permission had to be sought before any new service can be introduced in the market. With the full liberalisation of the telecommunications market, this premise has changed and the main regulatory concerns now for IDA are in managing the electromagnetic frequency spectrum as a scarce resource, overseeing the competition between players in a liberalised market and imposing regulatory controls where there is unfair competition or a lack of competition. Since the creation of SingTel in 1992, the partial liberalisation of the market in 1993 and full liberalisation in 2000, the players in the market has grown, with other major local players such as MobileOne and StarHub as well as international players such as MCI WorldCom and Reach International (a tie-up between Telstra from Australia and Pacific Century Cyberworks from Hong Kong) that provide telecommunication services in Singapore.

By comparison, the broadcasting sector is still tightly regulated. After SBA and SBC were created in 1994, SCV

was created in 1995 to build a hybrid fibre-coaxial cable network in Singapore. SCV provided cable television initially, before venturing into providing data services through its cable network as well. The construction of the broadband network around the country was completed in 1999. In 2001, a second over-the-air television broadcaster, MediaWorks, was licensed to operate in Singapore. MDA currently grants licences for providers of broadcasting services in and from Singapore as well as for the installation and ownership of broadcasting apparatus. These licences include those for satellite broadcasting satellite (broadcasting uplinking) and TV receive-only (TVRO) system, television (residential and non-residential TV, dealer and vehicle TV), radio (vehicle radio and dealer), Internet (ISP and Internet content provider) and video-on-demand services.

The regulatory perspective for the IT and e-commerce sectors is different from those of the telecommunications and broadcasting sectors. There is no issue of scarcity, and the main concerns of a policy maker in such an environment are to remove regulatory barriers (which may be in other sectors) that impede industry growth, clarify ambiguities of current laws and policies as they apply to cyberspace and, where necessary, create certainty on the rules by which players in cyberspace should abide by. The IT and e-commerce regimes tend to be enabling and proactive in nature, actively seeking out obstacles to be removed before they become real problems.

Legislation⁸⁴

Empowering IDA

In 1999, the *Info-communications Development Authority of Singapore Act*,⁸⁵ the *Telecommunications Act*,⁸⁶ and the *Postal Services Act*⁸⁷ empowered IDA as a regulator and provided for the regulation of telecommunications and postal services by IDA. After the telecommunications services sector was completely liberalised in April 2000, the *Code of Practice for Competition in the Provision of Telecommunication Services*⁸⁸ was instituted in September 2000 to regulate the competitive behaviour of the operators in the industry. The other subsidiary legislation under IDA include:

- *Telecommunication (Dealers) Regulations*⁸⁹
- *Telecommunication (Internal Wiring) Regulations*⁹⁰
- *Telecommunication (Class Licence for Postal Services) Regulations*⁹¹
- *Telecommunications (Class Licences) Regulations*⁹²
- *Telecommunications (Cable Detection Workers) Regulations*⁹³
- *Telecommunications (Radio-communication) Regulations*⁹⁴
- *Telecommunications (Composition of Offences) Regulations*⁹⁵
- *Telecommunications (Certificates of Competency for Ship Station Operators) Regulations*⁹⁶
- *Postal Services Regulations*⁹⁷
- *Postal Services (Composition of Offences) Regulations*⁹⁸

Empowering MDA

SBA derived its powers and regulatory role over the broadcasting sector from the *Singapore Broadcasting Authority Act*⁹⁹ passed in 1994. With the creation of MDA, the powers of the regulator are now derived from the *Media Development Authority Act* passed in 2002.¹⁰⁰ The Internet is classified as one of the broadcasting media. To regulate content on the Internet, the then SBA established a class licensing scheme through the *Singapore Broadcasting Authority (Class Licence) Notification*¹⁰¹ and the *Internet Code of Practice* (SBA, 1997). The class licensing scheme provides the framework under which content providers on the Internet are licensed, while the code establishes guidelines for acceptable content that can be published over the Internet. In addition, the *Parliamentary Elections (Election Advertising) Regulations 2001*¹⁰² provides rules under the class licensing scheme to enable previously disallowed Internet election campaigning activities to take place now. The other subsidiary legislation under the then SBA that now comes under MDA include:

- *Singapore Broadcasting Authority (Broadcasting and Television) Regulations*¹⁰³
- *Singapore Broadcasting Authority (Composition of Offences) Regulations*¹⁰⁴
- *Singapore Broadcasting Authority (TVRO System) Regulations*¹⁰⁵

A similar competition framework and code of practice has been developed for the broadcasting and print industry in light of the competition being introduced (SBA, 2001). The code is aimed primarily at preventing the two dominant players (SPH and MediaCorp) from abusing their dominant positions, as well as ensuring that social goals are not compromised by competition and quality is maintained (*Straits Times*, 2002a). The code has been circulated for public consultation and the finalised version was released on 1 April 2003 (SBA, 2002c).

Electronic Transactions Act

The *Electronic Transactions Act*,¹⁰⁶ administered by IDA, was passed in 1998 as an enabling legislation to remove the uncertainty around the legality of contracts that are formed electronically, to give recognition to electronic signatures and to clarify the liability of network service providers that merely carry traffic. It establishes the voluntary licensing of certification authorities as trusted third parties in the online world to provide the basis for other trust relationships to be established. The *Electronic Transactions (Certification Authority) Regulations*¹⁰⁷ stipulate the requirements for a certification authority to obtain a licence in Singapore, and the accompanying *Security Guidelines for Certification Authorities* (IDA, 1999) stipulate the technical security requirements that must be met. There are also provisions in the *Electronic Transactions Act* that enable government agencies to easily implement electronic systems to transact with the public without the need to amend their own parent legislation. The Act provides for the acceptance of electronic

applications and issuance of digital licences, with the ability to send and receive electronic documents in a reliable manner.

Computer Misuse Act

The *Computer Misuse Act*,¹⁰⁸ administered by the Ministry of Home Affairs¹⁰⁹ and the Singapore Police Force,¹¹⁰ was passed in 1993 to deal with increasing incidents of computer crimes that were not readily caught by the provisions under the existing *Penal Code*.¹¹¹ Before its enactment, criminal acts involving computers did not clearly fall under traditional crimes such as theft or criminal breach of trust, thus making it difficult for the public prosecutor to bring charges against offenders. The Act thus created new offences, specifically unauthorised access and modification of computer systems. In 1998, the Act was further amended to address new attacks that had evolved with the spread of the Internet (e.g. denial-of-service attacks). It also recognises that some computer systems are critical to Singapore (e.g. the system for banking and finance, emergency services and public services) and thus metes out harsher punishment for offenders who gain unauthorised access to such systems.

Evidence Act

The *Evidence Act*,¹¹² administered by the Ministry of Law, was first enacted in 1893 (was then the *Evidence Ordinance*) and governs the general admissibility of evidence in court. The Act was amended in 1995 to provide for the admissibility of computer output as evidence in court. The *Evidence (Computer Output) Regulations*¹¹³ were promulgated in 1997 to establish the criteria for certifying imaging systems that can archive documents in an electronic form to be recognised under the Act.

Copyright Act

The *Copyright Act*,¹¹⁴ administered by the Ministry of Law, MTI and IPOS, was passed in 1987. The Act primarily deals with the protection of copyright in works. Computer programs are included as copyrightable works. As various forms of works are increasingly available in electronic forms, it is important to prevent the making of illegal digital copies of works to protect the interests of the authors of those works. The Act was amended in 1999 to deal with the uniqueness of the electronic environment (e.g. clarification of the concept of temporary reproduction in the Internet browsing environment and introduction of “take down” provisions to deal with problems of unauthorised copies of works being made available through the Internet).

Voluntary codes and guidelines

In addition to legislation and regulations, voluntary codes and industry guidelines are used as tools to provide guidance to the ICT industry. These voluntary codes and guidelines are intended to provide industry players with an indication of the standards that they should abide by, and they do not operate as mandatory regulatory regimes.

Internet Content Code

NIAC, in 2002, issued an *Internet Content Code* to deal with the types of content industry players put on the Internet (NIAC, 2002a, pp. 23–26). The main obligations for content providers adopting the code are to observe the following:

- They are not to knowingly place inappropriate, objectionable, or illegal content on the Internet.
- They are to use their best efforts to ensure that no content deemed unsuitable for minors is made available to them freely on their service.
- They should adopt an appropriate content classification system to rate and label their websites.
- They are not to use inaccurate or misleading descriptors to rate and label their websites.
- They are to respect the privacy and confidentiality of user information.
- They are not to send unsolicited e-mails.
- They should comply with the *Singapore Code of Advertising Practice* published by the Advertising Standards Authority of Singapore.
- They should support public education initiatives and make available where possible information on filtering solutions and other content management tools.
- They should establish a process to address and investigate any public feedback or complaints, including cooperating with other industry members to carry out any remedial actions needed.

Data protection code

NIAC, also issued in 2002, a *Model Data Protection Code for the Private Sector* to articulate a set of principles governing the collection, use, safeguarding, etc., of personal information by service providers (NIAC, 2002b, pp. 51–78). The code provides for 11 data protection principles, differentiated roughly according to the different stages of data processing:

- *Accountability*: An organisation needs to be responsible for the personal data that is under its control, and there should be an individual within the organisation who is designated to be accountable to ensure compliance with the data protection policy.
- *Identifying purposes*: An organisation needs to identify the purpose for collecting the data either before or at the time of collection.
- *Consent*: An organisation needs to obtain the consent of the individual before the data is used for the identified purpose. The Code provides guidance on some exceptions to this principle.
- *Limiting collection*: An organisation should only collect data that is necessary for the purpose that is identified, and the collection should be done in a fair and lawful manner.
- *Limiting use, disclosure and retention*: An organisation should use or disclose data only with the consent of the individual or in accordance with the

Code. The organisation should retain the data no longer than necessary for the purpose.

- *Accuracy*: An organisation should strive to maintain the accuracy and completeness of the data for the purpose that it is collected.
- *Safeguards*: An organisation should take appropriate measures (e.g. security controls) to ensure that the data is adequately protected.
- *Openness*: An organisation should be open about its policies and practices regarding how it manages the data in its possession.
- *Individual Access*: An organisation should grant an individual access to the data that is held about him and give the individual the opportunity to amend the data to ensure accuracy and completeness. The Code provides guidance on some exceptions to this principle.
- *Challenging compliance*: If there is any issue about whether an organisation is in compliance with its data protection policies, a challenge may be taken up with the designated person accountable for compliance.
- *Transborder data flows (optional)*: Where an organisation transfers data to another country, measures should be taken to ensure that the data continues to be afforded the same protection when received in the other country.

The National Trust Council (NTC)¹¹⁵ conducted a public consultation on the application of the code in the online environment. NTC was formed in 2001 as an industry-led and government-supported effort to address concerns of the industry to build confidence in electronic transactions. It launched a national trust mark initiative called TrustSg¹¹⁶ to instil consumer confidence in e-commerce providers and create consumer awareness. The mark provides a visual indication to consumers and businesses as to the “trustworthiness” of online establishments. It covers concerns on fraud, credit card scams, fulfilment, data protection and security. Authorised code owners such as trade associations, chambers of commerce or other businesses can be accredited by NTC to issue and enforce the trust mark based on codes of practice. Following the public consultation of the code, NTC may implement a modified version of the code through its TrustSg programme.

Internet banking guidelines

The government through the Monetary Authority of Singapore issued in 2001 the *Internet Banking Technology Risk Management Guidelines* for financial institutions offering Internet banking services. The guidelines were updated and reissued in 2002. They set out the principles and the risk management process for banks offering Internet banking services to identify, access, measure and respond to technology risks. The government’s policy on Internet banking requires all banks to adopt and uphold high standards of risk management and security practices. The guidelines

were developed in consultation with the financial sector and the technology industry. Recognising the complexity and increasing risks related to Internet and other online technologies, and the need to address the threats and malicious attacks of hackers, the primary objectives of the guidelines are to require financial institutions to:

- establish a sound and robust technology risk management process
- strengthen system availability, security and recovery capability
- deploy strong cryptography to protect customer data and transactions

The guidelines have set out that the responsibility for putting in place proper risk management systems and adhering to the established security standard lies with the board and senior management of financial institutions. They are expected to continually monitor the adequacy and effectiveness of the instituted measures, policies and practices, and ensure that compliance and audit procedures are undertaken to ensure compliance with the guidelines (MAS, 2002).

Domain name dispute resolution

In the area of Internet domain name dispute resolution, the Singapore Network Information Centre (SGNIC),¹¹⁷ the Singapore Mediation Centre,¹¹⁸ the Singapore International Arbitration Centre¹¹⁹ and the Singapore Institute of Arbitrators have come together to develop a *Singapore Domain Name Dispute Resolution Policy* (SDRP) to manage the rising number of disputes over domain names and trademarks over the Internet.

The SDRP framework deals with disputes in the “.sg” domain and is based on ICANN¹²⁰ Uniform Domain Name Dispute Resolution Policy (ICANN, 1999) and the World Intellectual Property Organization’s¹²¹ guidelines for domain name disputes (WIPO, 2002). The framework provides an alternative to civil litigation for instances of disputes over such issues. This reduces the time and costs involved in resolving such disputes.

The requirements to be met when initiating a dispute resolution under SDRP are:

- The “.sg” domain name is identical or confusingly similar to a name, trademark or service mark in which the complainant has rights.
- The registrant has no rights or legitimate interests in respect of the domain name.
- The domain name has been registered or is being used in bad faith.

The parties in the dispute have a choice of whether the dispute should be mediated by an administrative panel or decided by the panel. The decision of the panel will be implemented by SGNIC, unless one of the parties applies to the court for the dispute to be decided by the court (SGNIC, 2001).

Consumer protection

The fundamental governing legislation for consumer protection in Singapore is found in the *Sale of Goods Act*,¹²² the *Supply of Goods Act*,¹²³ the *Unfair Contract Terms Act*¹²⁴ and the *Consumer Protection (Trade Descriptions and Safety Requirements) Act*.¹²⁵ The first three laws are largely similar to their UK equivalent. They essentially provide for the implied terms of a contract for the sale and supply of goods and restrict the application of unfair terms in a contract, such as an unreasonable exclusion of liability for injury or death due to negligence. The fourth law primarily deals with the correct description, labelling and marking of products.

There is an ongoing discussion about developing a new *Consumer Protection (Fair Trading) Act*, championed by the Consumer Association of Singapore.¹²⁶ It has been reported that the Act is expected to cover the areas of misleading advertising, false bargains and unethical sales practices and is likely to deal with refunds, uncollected goods, cooling-off periods for contracts, product recalls and second-hand goods (*Straits Times*, 2002b). Preliminary indications are that the Act may provide for civil remedies for an aggrieved party to take action against errant traders. It is unclear whether an Office of Fair Trading would be established to enforce the law and prosecute offenders. The draft Act to be prepared by MTI is also expected to undergo a public consultation.

WTO commitments

Singapore is a founding member of WTO. It participated in the Uruguay Round and ratified the WTO Agreement in 1994. Under WTO, Singapore has made commitments for basic telecommunications under the General Agreement on Trade in Services (GATS). Singapore was a full member of the Negotiating Group on Basic Telecommunications in 1995 and participated in the formulation of the multilateral framework on basic telecommunications. Singapore’s offer included guidelines on competition safeguards, network interconnection rules, transparency of regulations and independence of regulators. These are measures essential to ensuring a level playing field for telecommunications players. Singapore has maintained the position that flexibility is to be given to each country to adopt its own method of implementation since there are differences in the extent of competition and the level of telecommunications development in each country (WTO, 1996).

Singapore has signed the Fourth Protocol to GATS (Agreement on Telecommunications Services) and has committed to granting licences for up to two additional operators for public switched services and leased circuit facilities from 1 April 2000, replacing the previous offer, under which exclusivity was granted to SingTel until 2007. Singapore has in fact moved well ahead of its WTO GATS commitments. While under the WTO commitments, Singapore had planned to introduce competition by means of a duopoly in basic telecommunications until April 2002.

All restrictions on foreign investment were abolished in April 2000, and full competition was introduced two years ahead of schedule (WTO, 2000).

Under its commitment in the WTO Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement, Singapore has already reviewed its entire intellectual property regime and made the necessary amendments to the legislation through the *Copyright (Amendment) Act*.¹²⁷

Open source movement

In Singapore, the open source movement has started to pick up momentum and the government hopes to see industry players lead in promoting and developing products and services with Linux and other open source software platforms. Singapore's shipment of Linux-based computers accounted for about 2 percent of the total shipment of 12,000 in the first half of 2000 for Asia Pacific (excluding Japan), and that number is expected to increase to 100,000 by 2004 (IDA, 2001j). Linux is one of the technologies incorporated in the Infocomm Technology Roadmap and is also a skill set supported by CITREP (described earlier).

Some local educational institutions have included Linux in their curriculum. Temasek Polytechnic even has a Linux Lab; while NUS has an Open Source Software Lab, which has the objective of providing an environment for NUS students to learn software design and development skills through open source projects. The laboratory conducts R&D in wireless mobile Internet networking protocols, dealing with wireless and other new or emerging areas of technologies. It receives sponsorship from industry, including Ericsson Cyberlab Singapore¹²⁸ and the Centre for Wireless Communications.¹²⁹

IBM Singapore opened a new IBM Open Computing Centre in September 2002 and has committed to providing S\$40 million to the centre over the next three years. The centre is made up of the Web Services Innovation Zone, in collaboration with and located at Nanyang Polytechnic,¹³⁰ and the Linux Integration Zone, located at IBM's regional headquarters in Singapore. The centre promotes the adoption of Linux by business partners, customers and developers by providing a platform to build, test and deploy a wide range of Linux-based solutions (CMPnetAsia, 2002). The collaboration between IBM and Nanyang Polytechnic aims to promote open web services standards and allow developers to work with open standards programming models and deploy web services over multiple platforms (IDA, 2002q).

Schools such as Hwa Chong Junior College,¹³¹ Chinese High¹³² and Raffles Institution¹³³ have used Linux for their daily tasks, such as e-mail, Web server, database and file server to save the schools licensing costs. Much effort has been taken to ensure smooth transition of various servers to Linux, integrating the schools' Windows desktops and making it transparent to teachers and students.

The Singapore Linux Conference 2002¹³⁴ was held in October 2002. It featured case studies from businesses of

their experiences with open source platforms. The conference was organised by the Linux User Group of Singapore,¹³⁵ currently in its eighth year in Singapore. The group was started as a special interest group of the Singapore Computer Society in 1993 and was formally registered as a society in 1994. It has been instrumental in the development and awareness of the open source movement in Singapore and regularly organises events and training sessions.

Research into ICTs

Singapore, with a vibrant and competitive ICT environment, aims to attract global industry players to leverage Singapore as a living laboratory for innovation in Asia. Its integrated telecommunications infrastructure for both wireline and wireless systems as well as pro-business policies provide a conducive environment for R&D activities with a multi-ethnic and innovation-friendly population.

Given Singapore's global connectivity and accessibility to the Asian market, more than 6,000 multinational and local wireless players have established their wireless R&D and testbed activities in Singapore. Notable examples include Siemens, Ericsson Cyberlab, HP and Cap Gemini Ernst & Young (IDA, 2002j).

It has been surveyed that S\$3.01 billion was injected into Singapore's R&D sector in 2000. The private sector accounts for most of the expenditure, with 53 percent of private sector R&D spending directed at the electronics segment, 20 percent to engineering, 11 percent to ICTs, and 1.5 percent to biomedical sciences. The survey also indicated that 82 percent of the workers in the R&D sector are researchers, 9 percent are technicians and another 9 percent are support staff. Singaporeans and permanent residents make up 74 percent of R&D staff, while 26 percent are foreign citizens. Of the 82 percent classified as researchers, almost a third are foreigners. Among the research staff, 88 percent are classified as research scientists and engineers, with 37 percent of them having a doctorate or a master's degree (IDA, 2001t).

Infocomm Technology Roadmap

The government regularly publishes an Infocomm Technology Roadmap in collaboration with key industry vendors and operators, academia and research bodies. These roadmaps chart the trends and developments in technology, standards, industry and application deployment for a future period of up to five years. The purpose of the roadmap is to provide the tracks on which the development of Singapore's ICT industry should ride on to grow. This is intended to help the industry track and respond to ICT development trends. It aligns Singapore's technological direction with worldwide industry development and identifies key technologies¹³⁶ to focus on in the near future (IDA, 2002h).

R&D efforts

Specific ICT R&D efforts by the industry in Singapore include efforts from Siemens in collaboration with the then Centre for Wireless Communications and Kent Ridge Digital Labs (KRDL) to develop mobile Internet solutions (IDA, 2001s). Through the government's iTA scheme (described earlier), Siemens trained mobile Internet technology engineers from Singapore in its Munich facility, with the aim of having them form the core of Siemens' new R&D team in Singapore. Siemens has also opened its Siemens Information and Communication Mobilizer Wireless Center, drawing on its R&D strength.

The former KRDL, one of Singapore's most prominent R&D laboratories, (now the Laboratories for Information Technology),¹³⁷ has research laboratories for media engineering and management, language engineering and knowledge management, ubiquitous and distributed systems, and bioinformatics and medical imaging. It has a multidisciplinary staff from India, Malaysia, China, other Asian countries, Europe and the USA. It has a number of spin-offs, including NexusEdge and PixAround.¹³⁸

Other research efforts include the Network Technology Research Centre in NTU, which has conducted long-term research in optical networking and in photonics. The Institute of Microelectronics focuses on electro-optical-wireless packaging with core competencies in design, simulation, analysis, material characterisation, assembly, reliability assessment, modelling and failure analysis. The Institute of Materials Research and Engineering's competency is in developing new semiconductor devices for better performance (IDA, 2002c).

Grid-like architectures are expected to be developed where computing and connectivity services eventually become ubiquitous, robust and reliable like the power grid. An ICT training partnership between the government and the Bioinformatics Institute nurtures manpower in this emerging technology of grid computing (IDA, 2002i). This initiative equips trainees with the skills to participate actively in the deployment of cyber infrastructure to meet the needs of biomedical R&D in Singapore. It leverages on the government's iTA scheme (IDA, 2002g). The objective is to develop people to implement, manage and grow the cyber infrastructure underpinning the BioMedical Grid, a high-speed network of shared computing and data storage resources running bioinformatic applications used by biomedical researchers in Singapore, in collaboration with other R&D centres in the USA, Japan and Europe.

Future trends

At the opening of CommunicAsia/Broadcast Asia in June 2002 in Singapore, Singapore's Deputy Prime Minister and Minister for Defence unveiled a four-part plan to develop the ICT and media industry in Singapore in the following directions (IDA, 2002n):

Living laboratory and testbed

Singapore will be positioned as a living laboratory and testbed for ICT innovation. With an environment where one in four persons in Singapore is a broadband user and three out of four own a mobile phone, Singapore provides a conducive environment for the development and trial of innovative ICT products and services. A number of collaborative efforts are already in the works, and there are plans to continue to attract both international and local ICT companies to use Singapore as their location of choice for large and complex pilots and trials.

ICT R&D

The ICT R&D value chain will be strengthened. Given limited resources, the focus will be on strategic areas that are likely to yield high paybacks to Singapore and that optimise the deployment of its limited manpower resources and provide a seamless flow from research to development to "productisation" along the value chain.

Generation of demand.

A more sophisticated demand will be generated to drive sophisticated supply. Demand spurs industry to develop innovative solutions. Through e-government applications, a greater e-adoption among the people is generated. With the private sector providing more of its new and innovative services online, an even more sophisticated demand will be generated.

Aligning policy and regulatory environment

The policy and regulatory environment will be aligned with emerging trends. With the convergence of IT, telecommunications, broadcasting and media in Singapore, IDA will oversee both IT and telecommunications, while the new statutory board MDA will oversee the media and content industry (MITA, 2002b). Both IDA and MDA are placed under the purview of MITA, with an aim to develop a coherent and consistent policy and regulatory framework for the various converging sectors. This will help remove uncertainties and inconveniences for industry players and pave the way for the accelerated development of the new converging industries.

In the report of the Economic Review Committee's ICT Working Group, *Singapore 2012: The Living Digital Hub*, released in September 2002, the industry-led committee similarly highlighted the importance of the ICT industry to Singapore's economic growth and the need to position Singapore as a place to create, test, commercialise and deploy innovative and complex ICT solutions. The working group recommended that creative clusters be formed to foster innovation and experimentation, focusing on studying and

understanding how ICTs impact the lives of people. In recognising the large pool of intellectual property currently held by the government in the many ICT projects it has undertaken over the years, the working group recommended that the intellectual property currently held by various government agencies be consolidated and transferred to a central office to be sold or licensed to local enterprises. In the realm of policies, regulations and government structures, the working group also recommended that the functions across agencies should be reviewed and streamlined, and that the possibility of having a single ICT-focused agency as a single contact point for the development and promotion of the industry should be considered. In addition, a regulatory framework to cater to the converging environment needs to be put in place to address licensing, resource allocation and competition issues that are emerging.

While the current regulatory regimes for the communications infrastructure and content regulation are rationalised and streamlined, the promotional and development functions and e-government functions are likely to continue on their current track for the immediate future. New strategic areas to focus on may be identified, and an update on the Infocomm 21 strategic plan is expected. Efforts will continue in promoting the use of ICTs both in business and in everyday life. A careful balance is maintained between regulation and promotion to ensure that the industry can grow without undue distortion.

The ICT industry is a key component of the growing services sector in Singapore. As the country moves from being less of a manufacturing-based economy to more of a services-based economy, ICTs will be an important enabling tool and engine of growth. Complemented with the regional cooperative frameworks and strategic free trade arrangements with countries that are its major trading partners, Singapore can realistically be expected to achieve its aim of becoming an ICT hub. The government has expressed its commitment to continue to develop the ICT and media sectors into a major engine of economic growth as well as exploiting ICTs to boost the productivity and competitiveness of other sectors.

Select bibliography on Singapore

Infocomm Development Authority of Singapore (IDA) Web Site <<http://www.ida.gov.sg>>

The IDA website contains a wealth of up-to-date information concerning the national strategies, frame-works, policies, regulations, survey results, statistics, promotional activities, news releases and other publications and information pertinent to the ICT industry in Singapore.

Ministry of Trade and Industry (MTI)

<<http://www.mti.gov.sg>>

The MTI website publishes a variety of reports, information and statistics on the economic profile and outlook of Singapore.

Ministry of Information, Communications and the Arts (MITA) <<http://www.mita.gov.sg>>

The MITA website publishes a variety of reports providing a range of information about Singapore. In particular, the publication *inform.educate.entertain@sg: Arts & Media in Singapore* provides a snapshot of the media industry in Singapore, while *Singapore 2001* provides an overview of the country.

Singapore Statistics <<http://www.singstat.gov.sg>>

The Singapore Statistics website publishes the official statistics collected by Statistics Singapore (previously the Department of Statistics of MTI). The statistics cover a wide range of areas, including economic and social indicators as well as surveys from the regular population census.

Infocomm 21 Report

This report outlines the Infocomm 21 strategies and sets out the objectives and thrusts of the national strategy for the ICT sector.

IDA annual reports, 2000 and 2001

The IDA annual reports or year books summarise the main programmes and achievements of the ICT regulator and promoter in Singapore for the given year.

Singapore 2012: The Living Digital Hub

The report of the Economic Review Committee's ICT Working Group provides an analysis of the state of the ICT industry in Singapore, including its current strengths and weaknesses, and recommends measures that can help the industry to continue to grow and contribute towards the national economy.

inform.educate.entertain@sg: Arts & Media in Singapore

This publication provides a wide collection of facts and figures on the local arts and media scene. A new edition is produced about once in two years.

Effective Regulation Case Study: Singapore 2001 <http://www.itu.int/itudoc/itu-d/publicat/sgp_c_st.html>

This case study was conducted by ITU on the approach towards the regulation of telecommunications and ICTs in Singapore. The report provides a broad view of the evolution and development of the industry and the regulator in Singapore, as well as the current regulatory regime and approaches taken.

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Notes

1. <<http://www.sph.com.sg>>.
2. <<http://www.mediacorpsingapore.com>>.
3. <<http://straitstimes.asia1.com.sg>>.
4. <<http://business-times.asia1.com.sg>>.
5. <<http://newspaper.asia1.com.sg>>.
6. <<http://www.sph.com.sg/business.nsf/pages/streats>>.
7. <<http://corporate.mediacorpsingapore.com/press>>.
8. <<http://www.zaobao.com>>.
9. <<http://cyberita.asia1.com.sg>>.
10. <<http://tamilurasu.asia1.com.sg>>.
11. They include wire agencies such as Reuters <<http://www.reuters.com>>, Bernama <<http://www.bernama.com>>, the Associated Press <<http://www.ap.org>>, AFP <<http://www.afp.com/english/home>>, AFX-Asia, Bloomberg Business News <<http://www.bloomberg.com>>, Bridge News <<http://www.bridge.com>>, Kyodo News Agency <<http://home.kyodo.co.jp>>, ANSA News Agency <<http://www.ansa.it>>, Jiji Press <<http://www.jiji.co.jp>>, Central News Agency <<http://www.cna.com.tw>>, Xinhua News Agency <<http://www.xinhua.org>>, Dow Jones Newswires <<http://www.djnewswires.com>> and Pan-Asia Newspaper Alliance.
12. They include *International Herald Tribune* <<http://www.iht.com/frontpage.html>>, *New York Times* <<http://www.nytimes.com>>, *Asiaweek* <<http://www.asiaweek.com/asiaweek>>, *Yazhou Zhoukan* <<http://www.yzzk.com>>, *China Times* <<http://news.chinatimes.com>>, *Time* <<http://www.time.com/time>>, *Frankfurter Allgemeine Zeitung* <<http://www.faz.com>>, *Handelsblatt* <<http://www.handelsblatt.com>>, *The Hindu* <<http://www.hinduonnet.com>>, *Nihon Keizai Shimbun* <<http://www.nni.nikkei.co.jp>>, *Hokkaido Shimbun* <<http://www.hokkaido-np.co.jp>>, *Yomiuri Shimbun* <<http://www.yomiuri.co.jp/index-e.htm>>, *Sydney Morning Herald* <<http://www.smh.com.au>> and *South China Morning Post* <<http://www.scmp.com>>.
13. <<http://www.newsweek.com>>.
14. <<http://www.economist.com>>.
15. <<http://www.mediacorptv.com>>.
16. <<http://corporate.mediacorpsingapore.com/news/index.htm>>.
17. <<http://www.mediacorpradio.com>>.
18. <<http://www.sphmediaworks.com/index.phtml>>.
19. <<http://www.unionworksonline.com.sg>>, operated by NTUC (National Trade Union Congress) Media Cooperative Limited.
20. <<http://power98.com.sg>>.
21. <<http://www.nac.gov.sg>>.
22. <<http://www.bbc.co.uk/worldservice/index.shtml>>.
23. The role of SBA was taken over by the Media Development Authority (MDA) on 1 January 2003. Correspondingly, the references from SBA will likely be attributed to MDA later.
24. <<http://corporate.mediacorpsingapore.com/tvmobile>>.
25. <<http://www.channelnewsasia.com>>.
26. <<http://www.starhub.com.sg>>.
27. <<http://www.rediffusion.com.sg>>.
28. They include CNBC Asia <<http://www.cnbcasia.com>>, BBC <<http://www.bbc.co.uk>>, Reuters Television <<http://about.reuters.com/media/tvvideo>>, German Radio & TV, German TV (ZTV), Chinese TV Network, Chinese Radio International, Chinese TV Company, Swedish Broadcasting, Nihon Hoso Kyokai (NHK) <<http://www.nhk.or.jp/index-e.html>>, Kansai Telecasting Corporation <<http://www.ktv.co.jp/e>> and Nagoya Broadcasting Network.
29. They are Animasia International <<http://www.animasia.com.sg>>, AXN Service Co. BBC Worldwide, BLK Syndicate, Business News (Asia), Discovery Asia, <<http://www.discovery.com>>, ESPN STAR Sports <<http://www.espnstar.com>>, Expand Fast Holdings (Singapore), Home Box Office (Singapore) <<http://www.hbo.com>>, MediaCorp News, Music Television Asia <<http://www.mtvasia.com>>, Nickelodeon GNV Operations, SET Satellite (Singapore), Walt Disney Television (Singapore), and Worldspace Asia <<http://www.worldspace.com>>.
30. They are Four Media Company Asia, Film Formations, Infinite Frameworks <<http://www.frameworks.com.sg>>, Oak3 Films, Sunrise Entertainment, the Right Angle, the Moving Visuals Company <<http://www.movingvisuals.com>> and Video Headquarters.
31. <<http://www.nlb.gov.sg>>.
32. <<http://www.aseansec.org>>.
33. *Straits Times*, *Business Times*, *The New Paper*, *Computer Times*, *Shipping Times*, *Lianhe Zaobao*, *Berita Harian* and *Tamil Murasu*.
34. Arts and heritage services include An Explorer's Guide to Heritage Trails, Exhibitions and Festivals, Event Calendar, Fun Activities for Kids of All Ages, Resource Gateway, Arts and Heritage Education in Singapore, Need a Venue or Resource Information, and Funding and Support.
35. Business services include Business Planning, Legal Matters, Market Research, Innovation/Research and Development/Intellectual Property Rights, Taxation, Registration/Licences/Permits, Incentives and Grants, Business Premises, Human Resource, Finance, Market/Network/Find Partners, E-Commerce, Import/Export, Transportation/Logistics, Utilities, Enhanced Operations, Exit Strategies, Why Singapore? Go International/Venture Abroad, BizFile, and etrademark.
36. Defence services include Find out about National Services, Register for National Service, Pursue a Career with MINDEF, Apply for MINDEF/SAF Scholarship, Go Overseas, Pursue First Class Career, Go for IPPT, Do Business with MINDEF, and Give Feedback to MINDEF.
37. Educational services include Attend Kindergarten, Pre-School Teacher Qualification, Attend Primary School, Sit for PSLE, Attend Secondary School, Sit for GCE Exams, Attend JC/CI/Poly/ITE, Pursue University Education, Place Overseas Singaporean in Local School, Look for Textbooks and Supplementary Materials, Upgrade Your Skills, and Join the Teaching Profession.
38. This service allows one to check the names of electors.

39. Employment services include information on managing workforce, recruiting and training workers and individuals, job search facilities, and career planning and skills upgrading information and services.
40. Family services include Register Birth, Care for Your Child, Experience Youth, Find Your Soulmate, Care for the Elderly, Get Married, and Attend to a Demise.
41. Health services include Care for the Elderly, Seek Dental Care, Seek Hospital Services, and Seek Healthy Lifestyle.
42. Housing services include Buying a Property, Looking for a Property, Selling a Property, Renting a Flat, Moving House, Renovating Your Home, Developing a Property, and Enjoying Amenities.
43. Legal services include the Singapore Legal System, Legal Aid and Advice, Family, Wills and Estate, Court-related Information, Alternative Dispute Resolution, Bankruptcy and Winding Up, Land Information, Intellectual Property Rights, Technology-related information, Legal Education and Practice.
44. The library service is eLibrary Hub.
45. Recreational services include Park Recreation Activities, Park and Greenery, Places of Interest, Botanic Gardens Programmes, and Community Centre Activities.
46. Security and safety services include Filing Police Reports, Visiting an Inmate, Preparing for Civil Emergencies, Becoming a PR/Citizen, and Setting up a Society.
47. Sports services include Getting Started, Staying Fit, Learn a Sport, Where to Play, Exercise Safety, the Active Company, and Win for Singapore.
48. Transport services include Buy a New Vehicle, Maintain a Vehicle, Buy or Sell a Used Vehicle, De-register a Vehicle, Driving/Riding in Singapore, and Learn to Drive/Ride.
49. Travel services include Registration with Singapore Embassy, Check Visa Application, and Apply for Exit Permit from SAF/SCDF/SPF.
50. <<http://www.ipos.gov.sg>>.
51. <<http://www.surfip.gov.sg>>.
52. <<http://www.nus.edu.sg>>.
53. <<http://ivle.nus.edu.sg>>.
54. <<http://www.wizlearn.com>>.
55. <<http://www.ite.edu.sg>>.
56. <<http://www.ntu.edu.sg>>.
57. <<http://www.cisco.com>>.
58. <<http://www.smu.edu.sg>>.
59. <<http://www.sgh.com.sg>>.
60. Terabits per second. One terabit is one trillion bits or 1,000,000,000,000 bits.
61. The companies are identified based on various sources and surveys, such as Asiaweek 1000, BusinessWeek Global 1000, Fortune 1000, FinanceAsia's Asia's Best Companies, as well as the corporate earnings of companies listed on the Singapore Exchange.
62. <http://www.imec.be/ovinter/static_general/start_en.shtml>.
63. <<http://www.mei.co.jp>>.
64. <<http://www.st.com.sg>>.
65. <<http://www.stengg.com/elect/index.html>>.
66. <<http://www.egov.gov.sg>>.
67. <<http://www.ida.gov.sg>>.
68. <<http://www.pkiforumsingapore.org>>.
69. <<http://www.asia-pkiforum.org>>.
70. <<http://bma.org.sg>>.
71. <<http://www.sitf.org.sg>>.
72. <<http://www.asp-alliance.org.sg>>.
73. <http://www.aseansec.org/summit/infos4_afw.htm>.
74. <<http://www.e-aseantf.org>>.
75. <http://www.mti.gov.sg/public/FTA/frm_FTA_Default.asp?sid=12>.
76. MITA was formerly the Ministry of Information and the Arts, before being renamed when IDA was moved under its purview in 2001. It retained its acronym after taking on the additional portfolio for ICTs.
77. <<http://www.mti.gov.sg>>.
78. <<http://www.sedb.com>>.
79. <<http://www.iesingapore.gov.sg>>.
80. <<http://www.a-star.gov.sg>>.
81. <<http://www.spring.gov.sg>>.
82. <<http://www.minlaw.gov.sg>>.
83. <<http://www.agc.gov.sg>>.
84. The full text of Singapore's statutes can be found at <<http://statutes.agc.gov.sg>>.
85. *Info-communications Development Authority of Singapore Act* (Sing.), Rev. Ed. 2000, c. 137A.
86. *Telecommunications Act* (Sing.), Rev. Ed. 2000, c. 323.
87. *Postal Services Act* (Sing.), Rev. Ed. 2000, c. 237A.
88. *Code of Practice for Competition in the Provision of Telecommunication Services*, S. 412/2000.
89. *Telecommunication (Dealers) Regulations*, Rev. Ed. 1999, r. 7.
90. *Telecommunication (Internal Wiring) Regulations*, S 152/96, r. 9.
91. *Telecommunication (Class Licence for Postal Services) Regulations*, Rev. Ed. 1998, r. 11.
92. *Telecommunications (Class Licences) Regulations*, S. 187/2000.
93. *Telecommunications (Cable Detection Workers) Regulations*, S 196/2000.
94. *Telecommunications (Radio-communication) Regulations*, S. 114/2001.
95. *Telecommunications (Composition of Offences) Regulations*, S. 516/2001.
96. *Telecommunications (Certificates of Competency for Ship Station Operators) Regulations*, S. 44/2002.
97. *Postal Services Regulations*, Rev. Ed. 2002, r. 1.
98. *Postal Services (Composition of Offences) Regulations*, Rev. Ed. 2002, r. 2.
99. *Singapore Broadcasting Authority Act* (Sing.), Rev. Ed. 1995, c. 297.
100. *Media Development Authority Act* (Sing.), Act 34 of 2002.

101. *Singapore Broadcasting Authority (Class Licence Notification)*, Rev. Ed. 1997.
102. *Parliamentary Elections (Election Advertising) Regulations 2001*, S. 524/2001.
103. *Singapore Broadcasting Authority (Broadcasting and Television Regulations)*, S. 212/99, r. 1.
104. *Singapore Broadcasting Authority (Composition of Offences) Regulations*, S. 104/87, r. 2.
105. *Singapore Broadcasting Authority (TVRO System) Regulations*, S. 354/2001, r. 3.
106. *Electronic Transactions Act* (Sing.), Rev. Ed. 1999, c. 88.
107. *Electronic Transactions (Certification Authority) Regulations*, Rev. Ed. 2001.
108. *Computer Misuse Act* (Sing.), Rev. Ed. 1998, c. 50A.
109. <<http://www.mha.gov.sg>>.
110. <<http://www.spf.gov.sg>>.
111. *Penal Code* (Sing.), Rev. Ed. 1985, c. 224.
112. *Evidence Act* (Sing.), Rev. Ed. 1997, c. 97.
113. *Evidence (Computer Output) Regulations*, Rev. Ed. 1997.
114. *Copyright Act* (Sing.), Rev. Ed. 1999, c. 63.
115. <http://www.trustsg.org.sg/ntc_main.htm>.
116. <<http://www.trustsg.org.sg>>.
117. <<http://www.nic.net.sg>>.
118. <<http://www.mediation.com.sg>>.
119. <<http://www.siac.org.sg>>.
120. <<http://www.icann.org>>.
121. <<http://www.wipo.int>>.
122. *Sale of Goods Act* (Sing.), Rev. Ed. 1999, c. 393.
123. *Supply of Goods Act* (Sing.), Rev. Ed. 1999, c. 394.
124. *Unfair Contract Terms Act* (Sing.), Rev. Ed. 1994, c. 396.
125. *Consumer Protection (Trade Descriptions and Safety Requirements) Act* (Sing.), Rev. Ed. 1985, c. 53.
126. <<http://www.case.org.sg>>.
127. *Copyright (Amendment) Act*, No. 6 of 1998.
126. <<http://www.tp.edu.sg>>.
127. <<http://opensource.nus.edu.sg>>.
128. <<http://www.cyberlab.com.sg>>.
129. <<http://www.cwc.nus.edu.sg>>. Now called the Institute of Communications Research.
130. <<http://www.nyp.edu.sg>>.
131. <<http://www.hjc.edu.sg>>.
132. <<http://www.chs.edu.sg>>.
133. <<http://www.ri.sch.edu.sg>>.
134. <<http://slc.lugs.org.sg/index.php?topic=General>>.
135. <<http://www.lugs.org.sg>>.
136. These key technologies include XML, intelligent web services, peer-to-peer, optical networking, 10 Gb Ethernet, next-generation Internet, ultra-wide band, interactive media, knowledge discovery, pervasive systems, 3G/4G, ICT security, free space optics and next-generation wireless LANs.
137. <<http://www.krdl.org.sg>>.
138. <<http://www.pixararound.com>>.
139. The total population comprises all citizens and permanent residents with local residence as well as foreigners staying in Singapore for one year or more. Singapore residents refer to citizens and permanent residents with local residence.
140. <<http://www.singstat.gov.sg/keystats/annual/indicators.html>>.
141. Ibid.
142. <<http://www.singstat.gov.sg/keystats/mqstats/indicators.html>>.
143. <<http://www.singstat.gov.sg/keystats/annual/indicators.html>>.
144. <<http://www.singstat.gov.sg/papers/c2000/adr-literacy.pdf>>.
145. *Computer Industry Almanac*.
146. IDA (2002a).
147. <<http://www.isc.org/ds/WWW-200207/dist-byname.html>>.
148. IDA (2002a).
149. Ibid.
150. <<http://www.isc.org/ds/WWW-200207/dist-byname.html>>.
151. IDA (2002p).
152. IDA (2002). *About IDA. Corporate Brochure – Facts and Figures* <<http://www.ida.gov.sg>>.