.sg

Singapore

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Total population	4,588,600 (2007)[a]
Literacy rate	95.4% (2006) (among residents aged 15 years and over)[a]
GDP per capita	SGD 52,994 or USD 38,349.07 (2007) (1 USD = 1.38188 SGD)[a]
Computers per 100 inhabitants	72.61 (2006)[b]
Fixed-line telephones per 100 inhabitants	40.6% (January 2008)[c]
Mobile phone subscribers per 100 inhabitants	125.6% (January 2008)[c]
Internet users per 100 inhabitants	Dial-up only: 22.8% (January 2008)[c] If (dialup subscriptions + broadband subscriptions)/population: (1,047,000+3,396,000)/4,588,600 = 96.83% (January 2008)[c]
Domain names registered under .sg	852,520 (January 2008)[d]
Broadband subscribers per 100 inhabitants	74% (January 2008); Household penetration 78.2% (January 2008)[c]
Internet international bandwidth:	Submarine cable capacity: 28 Tbps (October 2007)[c] Direct international internet connectivity: 25 Gbps (October 2007)[c]

(Sources: [a]SingStat 2008a; [b]International Telecommunication Union 2008; [c]IDA 2008u; [d]Internet Systems Consortium 2008)

OVERVIEW

Singapore's Gross Domestic Product (GDP) was SGD 209,990.9 million in 2006, with a per capita GDP of SGD 46,832 (SingStat 2008a). The bulk of this comes from manufacturing, construction, utilities, wholesale and retail trade, hotels and restaurants, transport and communications, financial services, and business services.

Revenues in information and communication or infocomm technology (ICT) reached SGD 45.4 billion in 2006, an annual growth of 19.9 percent. Thirty-six percent of this was domestic, while 64 percent was export-oriented. Seventy-eight percent of households had access to a computer and 71 percent had access to the Internet in 2006, up from 74 percent and 66 percent respectively in 2005. The proportion of businesses with broadband access was 99 percent for organizations with 250 and more employees, 83 percent for organizations with 50–249 employees, 69 percent for organizations with 10–49 employees, and 44 percent for organizations with less than 10 employees. The number of infocomm personnel grew 7.5 percent from 111,400 in 2005 to 119,700 in 2006 (IDA 2008a).

As of November 2007, 95 percent of households had fixed-line telephones. Mobile phone penetration is at 116.1 percent, Internet dial-up penetration at 22.8 percent, and household broadband penetration at 76.9 percent (IDA 2008b).

The Singapore economy continues to grow, developing a highly competitive ICT market, attracting substantial foreign investment, and becoming the regional headquarters of international players. Singapore continues to redefine itself and find new and innovative niches to maintain an advantage amidst increasing competition from neighbouring countries with lower operating costs for companies. The presence of local and international players interacting in a freely competitive environment is a key characteristic of the country's continued success.

TECHNOLOGY INFRASTRUCTURE

Since articulating the Singapore iN2015 Masterplan to transform Singapore into an intelligent nation and global city powered by infocomm by 2015, the government has taken steps to realize the Next Generation National Infocomm Infrastructure (NGNII) consisting of the Next Generation National Broadband Network (NBN) and a wireless broadband network that includes *Wireless@SG*, a program for establishing free Wireless Fidelity (WiFi) access island-wide.

A Request for Proposal (RFP) was issued in December 2007 for parties to design, build, and operate the *passive* infrastructure of the Next Generation NBN intended to provide pervasive high-speed connectivity for both business and home users. Effective open access to downstream operators is at the core of this RFP. As a policy, there will be structural separation of the passive network operator from downstream operators. The Singapore government is prepared to provide a grant of up to SGD 750 million for the project. The infrastructure is expected to be fully available nationwide by 2015, supporting a range of new services such as high-definition video conferencing and telemedicine.

A separate RFP was issued in April 2008 for the operating companies riding on the passive infrastructure and retail service providers. To enable downstream service providers to have effective open access to the operating company's *active* infrastructure

of the Next Generation NBN, the RFP will require the operating company to be operationally separated from other operators. The Singapore government is prepared to provide a grant of up to SGD 250 million to the successful bidder. With the grant for the network operator mentioned above, the total grant the Government is prepared to provide for the Next Generation NBN is SGD 1 billion (IDA 2008c, 2008d, 2008v).

Complementing the Next Generation NBN is a Wireless Broadband Network in key catchment areas. Part of this effort is the *Wireless@SG* initiative (discussed in the next section). Several other complementary services are envisioned and a Call-For-Collaboration for Wireless Broadband Market Development has been initiated to look into several areas, including mobile payments (m-payment), machine-to-machine or wireless sensor networks, telematics (merging of automotive and telecommunications technology), and location-based services (IDA 2008e).

A milestones achievement in 2007 was the rollout of High Speed Downlink Packet Access (HSDPA) by mobile operators. HSDPA builds on the third generation (3G) network to offer wireless access at speeds of 3.6 Mbps, and up to 7.2 Mbps for certain hardware. The ready availability of handsets, portable digital assistant (PDAs), and computers with built-in HSDPA capabilities means even greater seamless network and data access for consumers on the move (ZDNet Asia 2006a). Individual mobile operators are also entering into agreements with other mobile operators in the region to offer reduced rates or even flat rate mobile data access across countries. Bridge Alliance's DataRoam service, for instance, offers a flat rate for data roaming across Australia, Hong Kong, India, Indonesia, Korea, Macau, Malaysia, the Philippines, Singapore, Taiwan, and Thailand with select operators (SingTel 2008).

Launched in December 2006, *Wireless@SG* aims to blanket Singapore with free WiFi coverage with over 7,000 hotspots to improve infrastructure and public access to the Internet. Users can enjoy free indoor and outdoor wireless broadband access of up to 512 Kbps in most public areas. The objective is to serve 'people on the move' or people who require broadband access while away from home, schools, and offices, such as students, tourists, business travellers, and enterprise users like insurance agents and real estate agents. Users can register an account with one of the appointed wireless operators, and they will be able to roam within any of the *Wireless@SG* coverage areas in a seamless manner, regardless of the operator's network (IDA 2008f).

Wireless@SG is to be provided free for the first three years. The program is very well received, with more than 750,000 signed-up subscribers by April 2008. It has also earned the international Wireless Communities Best Practices Award of the Wireless Internet Institute, under the 'Economic Development' category (WII 2008; ZDNet Asia 2008).

KEY INSTITUTIONS AND ORGANIZATIONS DEALING WITH ICT

The key institutions dealing with ICT in Singapore are:

- The Infocomm Development Authority of Singapore (IDA, www.ida.gov.sg) is the infocomm industry champion, the national infocomm master planner and developer, and the government CIO. Its strategic goal is to attract foreign investment and sustain long-term GDP growth through innovative infocomm technology development, deployment, and usage, in order to enhance the country's global economic competitiveness.
- The Media Development Authority of Singapore (MDA, www.mda.gov.sg) has a dual function: *(i)* to promote the growth of the media industry; and *(ii)* to manage content to protect core values and safeguard consumers' interests. Its long-term objective is to develop Singapore into a vibrant global media city, a creative economy, and a connected society.
- The Interactive Digital Media (IDM) Programme Office (www.idm.org.sg) is responsible for managing the SGD 500 million budget allocated by the National Research Foundation for the development of a strategic IDM research program. Its efforts include developing a critical mass of media enterprises and talents, internationalization of local IDM content and enterprises, and strengthening Singapore's role as a Digital Exchange to process, manage, and distribute digital assets. The IDM Programme Office is housed within MDA and is a multi-agency effort.
- The Ministry of Information, Communications, and the Arts (MICA, www.mica.gov.sg) aims to develop Singapore as a global city for information, communications, and the arts in order to build a creative economy, a gracious community, and a connected society with a Singaporean identity rooted in the people's multicultural heritage. The MICA is the supervising ministry for the IDA and the MDA.
- The Singapore Infocomm Technology Federation (SiTF, www.sitf.org.sg), Singapore's premier infocomm industry association, brings together 400 corporate members from multinational and local companies. Members receive assistance in business development, market intelligence, overseas trade missions, and networking and alliances. Its mission is to realize a profitable Singapore infocomm

industry with worldwide reach and recognition, by working with government agencies, other local trade associations, and international organizations.

- The Economic Development Board (EDB, www.edb.gov.sg) is the lead government agency for planning and executing economic strategies to enhance Singapore's position as a global hub for business and investment. It is a one-stop agency, supporting local and foreign investors in manufacturing and services as they seek more value-creating operations, higher sustainable returns, and new business opportunities. The infocomm and media sector is one of the industry sectors covered by the EDB.

In addition, Singapore universities and polytechnics each have a school of infocomm providing training and developing the pool of human resources needed by the industry.

ICT AND ICT-RELATED INDUSTRIES

Singapore has a diverse ICT industry consisting of companies specializing in hardware, software, IT services, telecommunication services, and content services. The industry's total revenue in 2006 was SGD 45.42 billion, a 19.9 percent growth from 2005. The hardware sector accounted for 53 percent of the total.

The domestic market was SGD 16.44 billion in 2006, representing a modest growth of 3.9 percent from 2005. There were revenue increases in all segments except telecommunication services and hardware. Telecommunication services account for the highest share in total revenues (33 percent in 2006, down from 41 percent in 2005), followed by hardware (25 percent in 2006, down from 29 percent in 2005). There were increases in the revenue share of software (from 4 percent in 2005 to 10 percent in 2006), IT services (from 16 percent in 2005 to 18 percent in 2006), and content services (from 10 percent in 2005 to 13 percent in 2006).

The bulk of infocomm industry revenues in 2006 came from the export market (64 percent), which grew by 31.4 percent, earning SGD 28.98 billion compared to SGD 22.06 billion in 2005. The hardware segment dominated the sector with 69 percent of the export revenue in 2006. Software revenue comprised 22 percent, IT services 5 percent, telecommunication services 3 percent, and content services 1 percent. Thirty-Seven percent of export revenue came from exports to North Asian countries, and 19 percent to the Association of Southeast Asian Nations (ASEAN) countries (the largest were 37 percent to Malaysia and 18 percent to Indonesia). Exports to Japan made up 33 percent, the highest proportion of export revenues in Asia, followed by India at 17 percent. In the Middle East, the highest proportion of exports was to the United Arab Emirates at 61 percent, while in the Americas/Europe, 43 percent of exports was to Western Europe, 27 percent to the United States (US), and 26 percent to Eastern Europe (IDA 2008g).

KEY ICT POLICIES, THRUSTS, AND PROGRAMS

Infocomm Adoption by SMEs

IDA's *Infocomm@SME* Programme aims to help small and medium-sized enterprises (SMEs) better exploit infocomm technologies through various initiatives such as:

- The SME Infocomm Resource Centre @ Singapore Polytechnic (SIRC@SP) aims to assist SMEs in the use of common software such as electronic mail, Internet voice, anti-spyware, anti-virus, and a wireless network setup. The centre offers businesses the opportunity to experiment with new systems and products before taking the decision to implement them.
- The Technology Innovation Programme (TIP) seeks to defray up to 50–70 percent of the cost of infocomm innovation of SMEs. SGD 5 million was set aside to help with business costs related to human resources, professional services, and hardware and software. Individual enterprises and groups may apply for support.
- Website creation services aim to encourage businesses to establish an online presence. Registered businesses will be able to save on the first year registration cost of Internet domain names.
- The Local Enterprise Technical Assistance Scheme (LETAS) can help SMEs with up to 50 percent of the cost of engaging external consultants for infocomm implementation.

Service providers are encouraged to form a consortium offering one-stop infocomm packages to help them operate more efficiently (IDA 2008h).

Digital Inclusion Programs

The NEU PC program is designed to ensure that all students have access to infocomm technology. The program has benefited more than 24,000 financially-challenged households with a monthly income of less than SGD 2,000 or a per capita income of less than SGD 500. Launched in 1999 to provide refurbished and new PCs with one-year free Internet dial-up subscription, the program now offers only new PC bundles. The most recent enhancement under the NEU-PC Plus program gives needy students and people with disabilities a new computer bundled

with three years of broadband access and a software package worth up to SGD 2,800, for only SGD 285. As of February 2009, another 4,200 families have benefited from this most recent enhancement. Those who cannot afford the subsidized cost of the package can co-pay through some form of community service under the iNfocomm Spark an Inspiring and Rewarding Experience (iNSPIRE) Fund contributed by industry and the government. Schools may tap the Ministry of Education's Opportunity Fund to help students own computers required for their school work. Other self-help groups, such as the Chinese Development Assistance Council and Singapore Indian Development Association, offer financial assistance to needy students (IDA 2008j).

Learning hubs called Silver Infocomm Junctions (SIJs) are being established to give senior citizens the opportunity to learn how to use new technologies, for example to make voice-calls over the Internet, meet and chat with friends online, and play computer games. This is part of a three-year Silver Infocomm Initiative aiming to equip 30,000 senior citizens with the infocomm skills necessary for a digital lifestyle. At least eight SIJs are expected to be established over three years.

In addition, an Infocomm Accessibility Centre (IA Centre) was established in mid-2008. Located with the Society for the Physically Disabled, the IA Centre houses an assistive technology library and three computer labs to offer industry relevant infocomm training and IT-related apprenticeship. The Centre is aims to train about 4,000 people with disabilities in three years, to increase their independence and job prospects (IDA 2008k).

Broadcasting

Commercial high-definition TV (HDTV) was launched in 2007, making Singapore the first country in Southeast Asia to offer such services. HDTV is available via cable and over-the-air terrestrial broadcast.

MDA is now working with industry to rollout broadcast TV on mobile phones — i.e. mobile TV services (MTVS).[1] Issues being considered include technical standards and quality of service requirements, licencing framework (kinds of licences to be issued), market structure (number of operators), and content and advertising regulation — i.e. the extent to which regulation of content should differ from regular free-to-air and subscription broadcast (MDA 2008b).

National Grid

The National Grid Pilot Platform (NGPP) has been established to facilitate computing-intensive services not only for the research and development (R&D) community but also for public agencies such as libraries and schools. The Grid is used for such applications as the Singapore Land Authority's land data hub and the National Library Board's Web Archive Singapore (WAS), an archive of snapshots of some 70,000 Singapore-registered websites with historical, heritage, and informational value. The grid provides the computing and processing resources to index and archive the pages. There are plans to take a snapshot of the entire Singapore Web domain in the near future. Students at Raffles Institution have also drawn on the power of the grid to develop AutoDock, a popular simulation-based application used in the drug development cycle. The Grid offers a cost-effective means of solving high-performance computing problems (IDA 2007).

Infocomm Security

Since the announcement of Singapore's Infocomm Security Masterplan in 2005, an Infocomm Security Health Scorecard has been introduced to help government agencies improve their overall infocomm security strategies and processes. Work on the Cyber-WatchCentre, which continuously monitors cyber threats to critical government infrastructure in real-time, has also begun. A first in Asia, the Cyber-WatchCentre will allow government agencies to better anticipate cyber attacks and respond more quickly to threats.

In April 2008, a new five-year Infocomm Security Masterplan was unveiled. It comes with a SGD 70 million budget to strengthen the local infocomm security industry's capacity to counter cyber threats. Priorities include raising the standards of infocomm security professionals through accreditation, certification, and training through a new Association of Information Security Professionals. It is recognized that there is a need to build on existing efforts to collaborate internationally, and enhance the exchange of knowledge and regular communication between governments on cyber threat trends and the protection of critical infrastructure. The NGNII security issues will need to be addressed, to create a secure and trusted environment for the pervasive adoption of online services (Business Times 2008b; IDA 2008l).

Government Standard Operating Environment

To help consolidate government procurement for infocomm services, the Singapore government announced in 2005 a Standard ICT Operating Environment (SOE) tender, which aims to standardize equipment across the entire government (including schools and statutory boards but excluding the Ministry of Defence) into a single collaborative environment.

Major vendors, both local and global, have come together to form consortiums to bid for the project (ZDNet Asia 2006b). The SGD 1.3 billion tender was awarded in February 2008 to oneMeridian, a consortium led by EDS International with partners including Alcatel-Lucent, Avanade, Cisco Systems, Frontline, Microsoft, Singapore Computer Systems, and SingTel. The project, envisioned to save the government some SGD 500 million over the next eight years, will be fully implemented by 2010 (IDA 2008t).

LEGAL AND REGULATORY ENVIRONMENT FOR ICT DEVELOPMENT

Spam

While general laws can be relied on to address problems created by spamming activities, there are always going to be loopholes that will invariably let undesirable spam through the net. To combat this, Singapore has enacted the Spam Control Act (see 'Singapore Spam Control Act 2007'). Its passage brought about an almost immediate change in the behaviour of marketers who use the Internet for outreach. They now label their messages as required by the law, and provide opt-out options. Internet service providers (ISPs) have policies for suspending email accounts from which spam originates. Consumer education seeks to raise awareness about how to avoid and counter spam. An informational website called the Singapore Spam Control Resource Centre (www.antispam.org.sg), supported by the IDA, the AGC, ISPs, and other industry associations, also consolidates a list of anti-spam resources, helping business and consumers fight spam.

Cybercrime

Criminal cases relating to the unauthorized use of unsecured wireless networks have been prosecuted in Singapore. In one case, the accused connected to his neighbour's unsecured wireless network (also known as 'wireless mooching') to chat online. He was charged under the Singapore Computer Misuse Act (CMA 1993). His arrest resulted from a complaint filed by

Singapore Spam Control Act 2007

The Spam Control Act (SCA) prohibits the use of dictionary attacks (defined in the Act as the method by which the electronic address of a recipient is obtained by using an automated means to generate possible electronic addresses by combining names, letters and other symbols in numerous permutations) or address harvesting software (defined in the Act as software designed or marketed for searching on and collecting from the Internet electronic addresses) to indiscriminately send unsolicited email.

With regard to unsolicited commercial electronic messages, the SCA sets out in Schedules the requirements that a sender must comply with, namely:

- Every unsolicited commercial electronic message needs to contain an 'unsubscribe' facility (e.g. contact information to submit an 'unsubscribe request').
- Every unsolicited commercial electronic message must contain the label '<ADV>' in the subject field or start of the message.

The SCA provides for civil actions to be taken against anyone (including those aiding or abetting) who sends electronic messages through the use of dictionary attacks or address harvesting software, or who sends unsolicited commercial electronic messages without complying with these requirements. An exception is provided for online or network access providers who merely provide connections for the transmission of data.

Anyone who has suffered a loss or damage as a result of spam may initiate civil action. An injunction may be granted by a court as a relief, or damages may be awarded based on the actual loss or damage suffered as a direct or indirect result of the action. The law also provides statutory damages of SGD 25 for each electronic message sent, not exceeding an aggregate of SGD 1 million, unless the actual loss is proven to exceed SGD 1 million.

The law also requires Internet access and telecommunication service providers to issue a code of practice indicating the minimum standards for technical measures to control the sending of unsolicited commercial electronic messages.

(Source: Government of Singapore 2007)

a passer-by who became suspicious of the teenager sitting by the road using his laptop late at night. The accused was sentenced by the district court to 18 months' probation (Channel NewsAsia 2007).

In another case, the accused posted an online bomb hoax while connected to a neighbour's wireless network. The message posted on a popular technology website stated that that there was a bomb at a local bus depot. The post was made just after the London subway and bus bombing in July 2005, causing alarm to other users of the site and prompting one of them to contact the police. The police identified the owner of the compromised wireless network, but later ascertained that the owner was not the author of the hoax. The accused also faced 60 charges of tapping illegally into nine unsecured wireless Internet networks over a period of eight months. The accused was sentenced to three months' imprisonment and fined SGD 4,000 (ZDNet Asia 2007a).

These two cases illustrate that the Singapore Police treat unauthorized wireless access seriously. They have said that they do not specifically track such offences but will investigate any allegation of cybercrime when it is reported.

Telecommunications

A Code of Practice for premium rate services over the public telecommunication network (e.g. mobile phone wallpapers, ringtones, and news alerts) has been issued. The code seeks to establish responsible business practices, define appropriate behaviour, and enhance consumer confidence. For instance, the cost of chargeable short message services (SMS) needs to be clearly indicated, and non-chargeable messages need to be sent to consumers to confirm subscriptions and remind them about charges. In addition, the IDA has issued a consultation paper on the industry structure for next-generation access networks, seeking views on the scope of separation, particularly in terms of types of operator, network elements, markets, or other differentiation (Business Times 2008c).

True number portability is expected to be in place in 2008 with the Central Database Administration of all numbers appointed. The central database will encourage new players and new opportunities, giving consumers greater choice and flexibility in mobile and fixed line services. SGNIC, the national registry for Internet domain names, has also started to allow pure numeric domain names, such as 1234.sg (IDA 2008l).

The Singapore government is seeking to promote nationwide IPv6 transition through the inclusion of IPv6 elements in the NGNII, government procurement policies, and industry capability building, thus (IDA 2006):

- The Next Generation NBN will need to support emerging next generation services and incorporate Internet Protocol version 6 (IPv6). Networks to be deployed will need to interoperate with new and existing infrastructure to enable a seamless end-user experience.
- The government as a major buyer will be a key catalyst of the transition to IPv6. A progressive replacement of public sector equipment with IPv6 capable equipment will be undertaken when the current equipment is due for replacement. In view of the expected tight supply of Internet Protocol version 4 (IPv4) addresses, 2010 has been set as the deadline for full public sector transition to IPv6.
- A national IPv6 Task Force with relevant experts from government, industry, and research institutes will recommend a technical transition plan for migrating from IPv4 to IPv6, as well as facilitate a broader understanding of the benefits of IPv6 and develop industry capability in IPv6 technologies.

IP Television (IPTV)

A new licencing framework for Internet Protocol Television (IPTV) has been instituted by the MDA in anticipation of the rollout of commercial IPTV services and to facilitate the growth of the sector. IPTV allows video or television signals to be transmitted over an Internet-based infrastructure and a set top box connected to the television. There are two tiers in the new framework:

- Nationwide Subscription TV Licence — for services that have a wide reach and impact beyond 100,000 subscribers. The Nationwide Licence is similar to that for a mass market pay TV operator.
- Niche Subscription TV Licence — for services that have limited reach and impact (100,000 subscribers or less). A lighter licence framework will be applicable to such licencees. For example, there will be no requirement to carry the local free-to-air channels. Services with a subscriber base exceeding 100,000 subscribers may still qualify as a niche player if they are targeting niche market segments. They will be assessed on the basis of location (whether the service is offered to specific non-residential locations in Singapore), language (whether there is a high proportion of foreign language content), and the reach and impact of the channels.

The licencing framework is intended to allow for more players to enter the market to offer more diverse forms of

programming content for both mass and niche audiences. The framework offers flexibility, which is expected to be more business-friendly (MDA 2008c).

DIGITAL CONTENT

Online Gaming

Singapore continues to recognize the value of developing an online gaming industry, estimated to be worth about USD 48.9 billion worldwide, with the Asia Pacific region contributing about 40 percent. Singapore's goal is to become a centre for the creation and commercialization of digital media and entertainment technologies, and a global node providing core services for storing, trading, and distributing digital assets. Singapore has more than one million square feet of data centre space available for hosting operations and 28 Tbps of submarine cable capacity connected to more than 100 countries, with a next generation broadband network in the pipeline (MICA 2007).

IDA has initiated the Games Exchange Alliance (GXA) to help companies commercialize their game titles in Asia. GXA has signed a memorandum of intent with various Asia Pacific game associations to facilitate business collaborations among members. It seeks to provide game service providers, publishers, content developers, and solution providers with market access to over 13 key Asian markets, including Australia, China, Hong Kong, India, Japan, and Taiwan. Following the Government's lead, private sector participants such as Razer, a PC gaming peripheral maker, has announced that it will increase its R&D capabilities in Singapore by investing USD 12.64 million over three years (ZDNet Asia 2007c).

The INVIGORATE scheme aims to provide aspiring game developers with funding of up to SGD 25,000 for each project, as well as mentorship with established game studios and publishers. Participants will be provided guidance on core business, design and production management aspects of mobile game development, and assistance in enhancing concepts for deployment. The scheme aims to expand Singapore's talent pool for game development (ZDNet Asia 2007d).

Interactive Digital Media (IDM)

To build the foundation of an ecosystem for IDM, close to a hundred projects were funded in 2007 to create new patents and products, and to nurture researchers and engineers in animation, games, effects, intermediary services of distribution and security of digital media, and 'on-the-move' technologies for reaching and interacting with mobile users. A network of business mentors has been formed to encourage experimentation with innovative applications and services, with participation from NUS Enterprises, NTU Ventures, FrontEdge Capital, Expara, and Thymos Capital. The network will help start-up companies overcome initial hurdles in getting the business running. Some successes observed include First Meta, a six-month start-up in financial services that was shortlisted for Red Herring 200 Global 2007.

Local flagship media and technology companies, SMEs, and major international companies are also encouraged to create synergies from collaboration, and to engage in R&D. Institutes of higher learning and research institutes are working with local counterparts to attract talents to make the country a centre for Interactive Digital Media (IDM) research and innovation. One success is the Singapore–MIT GAMBIT game lab where Singapore students had the opportunity to intern at the Massachusetts Institute of Technology (MIT) in 2006 to develop games. The China-Singapore Institute of Digital Media is a collaboration with the Chinese Academy of Sciences Institute of Automation (CASIA), which focuses on language mediation technology. The Singapore Ministry of Education has also established an R&D program to fund projects to build the capacity of schools to use IDM for teaching and learning (MDA 2008a).

ONLINE SERVICES

Common Online Identification System

The Singapore Personal Access (SingPass) system first launched in 2003 as a single log-on system for citizens and residents to access a range of government services, was upgraded in 2007 to streamline the log-in process and to allow users who have forgotten their passwords to reset them immediately. Transactions using SingPass increased more than threefold in four years from 4.5 million in 2003 to 18.9 million 2006. Previously administered by the Central Provident Fund, a government agency, the system will be managed by the private sector henceforth, although ownership will remain with the government with safeguards to ensure smooth running and confidentiality of user information (IDA 2008m).

EzCode

EzCode is an IDA initiative to give government, the private sector, and the public a free and secure two-dimensional (2D) barcode platform on a pilot basis. It allows camera-equipped mobile phones with downloaded software to easily decode 2D

barcodes, which contain more information than one-dimensional barcodes.[2] The decoded 2D barcode will then lead a user to online resources containing more detailed information. The technology has a wide range of applicable uses, including ticketing (e.g. printed with posters in mail and newspapers), location-based services (e.g. located at bus and taxi stands for schedule and bookings services), information discovery (e.g. outdoor advertising), payment (e.g. bills), and identification verification (EzCode 2008).

Mobile Payment

A range of different mobile payment (m-payment) and m-commerce providers are already in the market, but they are engaged in uncoordinated efforts using a variety of technologies from SMS to Java 2 Micro Edition (J2ME) applications. To avoid an unduly fragmented market that may dilute end-user experience, and to address potential issues relating to settlement, security, bad debt and repudiation, the Singapore government is seeking information from the industry on their capabilities and the possibility of converging local payment acceptance through a unified standard (CEPAS) for proximity payments. This is being undertaken under the broader Call-for-Collaboration for Wireless Broadband Market Development — described earlier (IDA 2008e).

Cluster Development Programs

As part of the iN2015 Masterplan, various cluster development projects have been deployed to transform key economic sectors by leveraging on infocomm. A project in the tourism, hospitality, and retail sector is the Digital Concierge program (www.digitalconcierge.sg), a joint effort of the IDA and the Singapore Tourism Board to provide every visitor with personalized information and services through mobile network devices via the cellular network and the *Wireless@SG* infrastructure. The service gives users suggestions on activities, restaurants, shops, attractions, and retail promotions, as well as event updates, based on preferences and location. The pilot project seeks to identify technology and business issues for planning long-term deployment (IDA 2008i).

In the trade and logistics sector, the Wireless-broadband-access for SEaPORT (WISEPORT) project will allow all ships in Singapore to have access to low-cost mobile wireless broadband using Worldwide Interoperability for Microwave Access (WiMAX) technology. This will facilitate real-time and data-intensive communications and applications between the ships and their customers and business partners previously possible only onshore. WISEPORT is one of the initial projects under the SGD 12 million Infocomm@SeaPort program to provide mobile wireless broadband within 15 kilometres of Singapore's southern coastline. Applications being explored under Infocomm@SeaPort, which is a collaboration between the Maritime and Port Authority of Singapore and the IDA, include optimizing car transhipment planning and operations, and automating some of the current labour-intensive processes in the bunker supply chain. A Call-For-Collaboration will be initiated to develop new WISEPORT content and applications for the seaport community, such as messaging and communication services, booking of maritime services, and real-time access to navigational data (IDA 2008n).

Launched in October 2007, TradeXchange is a platform for exchanging information within the trade and logistics community that allows seamless interconnection between commercial and regulatory systems through a single electronic window for integrated workflow, submissions, and enquiries to the seaports, airports, maritime authorities, customs, and other controlling agencies. The new platform has been well-received by the trading community in Singapore. Companies have experienced faster turnaround time and lower costs for declaration preparation and submission, and duplicate data entry has been eliminated, thus resulting in faster clearance and greater productivity. TradeXchange is developed and operated by CrimsonLogic, and builds on their earlier experience of developing TradeNet, the world's first trade documentation system, launched in 1989 (TradeXchange 2007).

For the healthcare and biomedical sector, the Integrated Clinic Management System (CMS), an SGD 15 million four-year program, was launched in September 2007 to encourage general practitioners' clinics to adopt and leverage common standards and interface to facilitate operations and improvements in patient care. To date there are 350 clinics on the CMS program (IDA 2008s).

ICT-RELATED EDUCATION AND CAPACITY-BUILDING PROGRAMS

In 2006, the number of infocomm personnel in Singapore reached 119,700, a 7.5 percent increase from 2005. Infocomm job vacancies totaled 2,100 in 2006, with the highest proportion of job categories required in software design, development, and solution implementation (29 percent), followed by database management (15 percent). Forty-six percent of infocomm personnel held a bachelor's degree, 5 percent had a postgraduate diploma, 10 percent had a master's degree, and 1 percent had a doctorate degree. The remaining 39 percent held a diploma or below. The largest proportion of infocomm personnel was

in the age group of 30–39 years old (49 percent), followed by 29 years or below (25 percent) and 40–49 years (20 percent). The top three job categories were infrastructure support (23 percent), software design, development and solutions implementation (20 percent), and infocomm sales and marketing — 15 percent (IDA 2008o).

Having a strong base of infocomm human resources is essential both for developing a domestic industry and encouraging high adoption of technology. The Singapore government aims to increase the number of infocomm jobs from 115,000 to 170,000 by 2015. The focus is on developing infocomm competencies in key economic sectors, developing globally competitive professionals, and attracting and retaining talents. Some of the key programs are (IDA 2008p):

- The CXO Programme seeks to inspire business leaders in key sectors about the value of infocomm through breakfast forums, seminars, and site visits.
- The InSkills@Work Programme aims to equip professionals in all sectors with skills to use technology effectively and productively.
- The Critical Infocomm Technology Resource Programme (CITREP) provides infocomm professionals with training incentives and supports course and examination fees for endorsed courses and certifications. The National Infocomm Competency Framework (NICF) defines the training and certification requirements in an infocomm professional's career.
- The National Infocomm Scholarship identifies and cultivates future industry leaders through scholarships and training opportunities with leading companies.
- The Infocomm Clubs Programme for schools aims to create interest in students from a young age through training, project work, mentorship, competition and collaborations between schools.
- The National Infocomm Competitions aims to raise general awareness of opportunities in the infocomm field.
- To bridge the digital divide and create an integrated society in Singapore where infocomm awareness is pervasive and access is available for all, technology will be used to help the needy, elderly and differently abled to enrich their quality of life.

A National Infocomm Competency Framework (NICF) has been set as a human resource planning tool. Based on standards agreed by industry, it seeks to both widen and deepen the capabilities of professionals and serve as a comprehensive guide for training and certification for the full range of infocomm jobs. The framework allows professionals to assess their own skills against established standards and to plan their career paths. It helps employers with their staff development programs. The framework also seeks to help training providers, with the design of training and certification programs, and ensure greater quality assurance in training and assessment (IDA 2008q).

A Call-For-Collaboration has been issued for the FutureSchools@Singapore project to transform the educational experience through infocomm. Five 'future' schools have been selected, and industry has been invited to participate in an open exchange to design and deploy solutions, products, and services. New forms of content like videos and interactive textbooks, as well as game-based learning and augmented reality learning environment with multi-user interaction, will be used to suit different learning styles.

The work in FutureSchools will be tapped to further develop Games for Learning and Learning Trails, as well as a Learning Digital Exchange where teachers and students can access educational content provided by educational institutions and commercial content providers. The content would be linked to other public resources from libraries and other archives. A technology development plan will provide a guide for schools in their innovations (IDA 2008r).

BackPack.NET provides a platform for interaction and sharing of experiences and ideas among educationists. The system gives access to a range of teaching and learning resources, and an opportunity to network through community and discussion forums. The objective is to bring together researchers, industry developers and schools to create new innovations for learning. The system enables the incubation of emerging technologies in education, an infrastructure for solution development, and collaboration between industry partners. It covers a range of pilot trials to experiment with and evaluate the use of new technologies, such as digital inking devices and specific educational applications through tools such as the tablet PC. Part of the program is the Classroom of the Future, which facilitates the visualization and showcasing of how technology can be incorporated into day-to-day learning in the future. In short, BackPack.NET enables R&D in education technology and nurtures a developers' community for technology incubation and development (BackPack.NET 2008).

OPEN SOURCE/OPEN CONTENT INITIATIVES

Singapore adopts a technology-neutral and pro-competition approach. There is increasing awareness about the availability of different types of software, including open source software. Both open source and commercial software solutions are deployed

in industry and the government sector in a complementary manner. Software choices and selections are made by individual purchasers based on individual needs, merits and requirements, and the adoption of open source software among companies and government agencies is growing at a modest pace.

A new project championed by Red Hat called the Open Source Collaborative Innovation aims to increase the number of Linux-based business applications in Singapore, and to expand the pool of available expertise. This is part of the IDA's infocomm Local Industry Upgrading Programme (iLUP) that seeks to upgrade the skills of local companies with support from international firms. Red Hat is also working with local academic institutions to teach Linux skills. Collaborative efforts include a new training facility in conjunction with Singapore Polytechnic to offer Linux resources to IT professionals, an open source think-tank with the Institute of Technical Education, and a centre for the development of commercial open source applications with Temasek Polytechnic (Business Times 2008a).

There are advocates calling for government to take a more proactive role in the use of open source, but the government recognizes the need to maintain a level playing field for all, and to allow products and companies to compete based on merit. There are some who believe that organizations may be more reluctant to try open source software, as they are often sufficiently funded to be able to spend on proprietary software, and cost savings from open source software implementations are not always present (ZDNet Asia 2007b). However, it is also self-defeating for advocates to call for preferential treatment of open source products as this implies that such products are not able to compete with commercial alternatives on their own merit.

RESEARCH AND DEVELOPMENT

There were 951 organizations performing R&D in Singapore in 2005, up from 811 in 2004. Of these, 900 are from the private sector, nine are from higher education institutions, 26 are from government, and 16 are public research institutes. The total R&D expenditure was SGD 4,582.2 million in 2005, up 12.8 percent from SGD 4,061.9 million in 2004. Sixty-six percent of the total R&D expenditure comes from the private sector, and 56.7 percent of total expenditure was in the area of engineering and technology. The total number of patents owned in 2005 was 3,475, up from 2,570 in 2004. In 2005, 1,594 patents were applied for and 877 patents were awarded (SingStat 2008b).

The Singapore government will set aside SGD 1.4 billion over five years to fund the development of three R&D areas that are key to the country's economic future: biomedical sciences, environmental and water technologies, and interactive and digital media. The aim is to create 86,000 jobs in these areas with a value added of SGD 30 billion by 2015 (EnterpriseOne 2008).

CHALLENGES

War for Talent and Quality of Jobs

The infocomm sector in Singapore faces increased competition from multi-service Asian firms and low-cost talents. After 25 years of developing the infocomm sector, it is noteworthy that there are no world-class icons in terms of high-value technology firms or software companies in Singapore. The best and brightest students are being drawn to softer sectors such as banking, finance, business, and sales. While the Singapore government recognizes the war for talent and the need to attract and sustain talented personnel who can innovate to exploit infocomm, it remains to be seen whether human resource development programs will succeed in shifting the infocomm industry to a higher-value trajectory.

Privacy and Data Protection Framework

It has been more than five years since the Singapore government recommended the use of an industry Code of Practice to address concerns regarding privacy and data protection (IDA 2002). Although spam legislation has been put in place, proper control of data held by organizations remains industry self-regulated. The growing trend worldwide is for some form of legislative framework to be put in place to set boundaries relating to the use of such data, and to allow consumers the ability to verify the accuracy of the information and prevent abuse. Such a framework will complement the spam control framework, which also deals with handling sensitive personal information such as electronic mail addresses and mobile phone numbers that are collected by organizations. It would be timely for the Singapore government to revisit the establishment of a legal framework concerning privacy and data protection of private personal information in Singapore.

Governing Philosophy toward Innovation and Competition

At a regional forum for government officials in Asia, the former chairman of IDA articulated three principles that are essential for managing innovation in a country — the market must lead the government; governments cannot have favourites but must consider all objectively; and governments need to be circumspect about the extent of engagement in economic management. He believed that these key principles make companies more efficient and competitive in the global market. If the companies cannot compete overseas, there is a limit to which they can be supported by the state. He believed in the role of governments as referees, and added that they need to be completely technology-neutral,

and to refrain from trying to pick winners and losers. Governments need to both encourage foreign investment as well as develop local companies and talents. Drawing from Singapore's experience, he highlighted the positive effects of liberalization and competition, noting that foreign investment is attracted by the establishment of a robust legal regime, which also serves to provide a conductive environment for local firms to grow. Indeed, competition is essential for innovation. If there is no competition or threat of competition, there will be no innovation. This is a challenge that many governments today need to address.

NOTES

1. The over-the-air broadcast signals will be received by mobile phones and other portable devices directly (in a point-to-multipoint manner) rather than being transmitted via the cellular network (in a point-to-point manner, which limits the number of concurrent users).
2. See www.barcodeman.com/faq/2d.php for an illustration of the differences between 1D and 2D barcodes.

BIBLIOGRAPHY

BackPack.NET (2008). *E-Community portal*. Retrieved 25 January 2008 from http://www.backpack.com.sg/default.aspx

Business Times. (2008a). *Red hat goes on partner offensive*. BizIT Section. p. 40, 10 April.

———. (2008b). *Govt unveils new masterplan to fight cyber threats*. p. 8, 18 April.

———. (2008c). *New rules may transform S'pore telcos*. p. 1, 18 April.

Channel NewsAsia. (2007). *Wireless piggybacking case sets precedent: experts.* Retrieved 25 January 2008 from http://www.channelnewsasia.com/stories/technologynews/view/266368/1/.html

EnterpriseOne. (2008). *S$1.4 Billion to Fund R&D in Singapore.* Retrieved 28 January 2008 from http://www.business.gov.sg/EN/News/Jul2006/20060710Billiont.htm

EzCode. (2008). *Possible applications.* Retrieved 30 January 2008 from http://www.ezcode.com.sg/possibleapplications.aspx

Government of Singapore. (1993). *Computer Misuse Act (CMA)*. Retrieved 30 January 2008 from http://statutes.agc.gov.sg/non_version/cgi-bin/cgi_retrieve.pl?actno=REVED-50A&doctitle=COMPUTER%20MISUSE%20ACT%0a&date=latest&method=part&sl=1

———. (2007). *Spam Control Act.* Retrieved 30 January 2008 from http://statutes.agc.gov.sg/non_version/cgi-bin/cgi_legdisp.pl?actno=2007-ACT-21-N&doctitle=SPAM%20CONTROL%20ACT%202007%0a&date=latest&method=part&sl=1

Infocomm Development Authority of Singapore (IDA). (2002). *News and events — Close of public consultation on model data protection code for private sector*. Retrieved 25 January 2008 from http://www.ida.gov.sg/News%20and%20Events/20061115143036.aspx?getPagetype=20

Infocomm Development Authority of Singapore (IDA). (2006). *Information paper — Internet Protocol Version 6 transition plans for Singapore*. Retrieved 25 January 2008 from http://www.ida.gov.sg/doc/Policies%20and%20Regulation/Policies_and_Regulation_Level2/white_papers/p-IPv6_white_paper_v2__posted_.pdf

———. (2007). *iN.SG — December 2007 — Grid computing makes inroads into public agencies*. Retrieved 29 January 2008 from http://www.ida.gov.sg/InSG/Dec07/egov.html

———. (2008a). *Publications — Facts and figures*. Retrieved 24 January 2008 from http://www.ida.gov.sg/Publications/20061130175201.aspx

———. (2008b). *Publications — Statistics on telecom services* for 2007 (Jul–Dec). Retrieved 24 January 2008 from http://www.ida.gov.sg/Publications/20070815141811.aspx

———. (2008c). *Infrastructure — Wired*. Retrieved 28 January 2008 from http://www.ida.gov.sg/Infrastructure/20060919190208.aspx

———. (2008d). *News and events — Singapore's ultra-high speed digital highway ready by 2015*. Retrieved 28 January 2008 from http://www.ida.gov.sg/News%20and%20Events/20071211184512.aspx?getPagetype=20

———. (2008e). *Infrastructure — Wireless*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Infrastructure/20060816192935.aspx

———. (2008f). *Programmes — Wireless@SG Programme*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Programmes/20061027174147.aspx?getPagetype=36

———. (2008g). *Annual survey on Infocomm Industry for 2006*. Retrieved 24 January 2008 from http://www.ida.gov.sg/doc/Publications/Publications_Level2/20061205092557/ASInfocommIndustry06.pdf

———. (2008h). *Infocomm Adoption — Small and medium-sized enterprises*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Infocomm%20Adoption/20070618182747.aspx

———. (2008i). *Programmes — Digital concierge*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Programmes/20070622132012.aspx?getPagetype=34

———. (2008j). *Programmes — NEU PC plus programme*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Programmes/20060419155649.aspx?getPagetype=34

———. (2008k). *iN.SG January 2008 — Special report Part 3*. Retrieved 25 January 2008 from http://www.ida.gov.sg/InSG/Jan08/sr3.html

———. (2008l). *iN.SG January 2008 — Special report Part 4*. Retrieved 25 January 2008 from http://www.ida.gov.sg/InSG/Jan08/sr4.html

———. (2008m). *News and events — SingPass enhanced to improve user experience with online government services*. Retrieved 28 January 2008 from http://www.ida.gov.sg/News%20and%20Events/20071105103244.aspx?getPagetype=20

———. (2008n). *News and events — Singapore's seaport to be world's first Wi-Max-ready by 2008*. Retrieved 28 January 2008 from http://www.ida.gov.sg/News%20and%20Events/20070925180233.aspx?getPagetype=20

Infocomm Development Authority of Singapore (IDA). (2008o). *Annual survey on Infocomm Manpower for 2006*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Publications/20070823161636.aspx

Infocomm Development Authority of Singapore (IDA). (2008p). *Manpower — Overview*. Retrieved 25 January 2008 from http://www.ida.gov.sg/Manpower/20060414201723.aspx

———. (2008q). *Programmes — The National Infocomm Competency Framework (NICF)*. Retrieved 29 January 2008 from http://www.ida.gov.sg/Programmes/20061016172720.aspx?getPagetype=35

———. (2008r). *iN.SG January 2008 — Special report Part 2*. Retrieved 25 January 2008 from http://www.ida.gov.sg/InSG/Jan08/sr2.html

———. (2008s). *Integrated Clinic Management Systems (CMS) Programme*. Retrieved 17 March 2008 from http://www.ida.gov.sg/Programmes/20061214184030.aspx?getPagetype=34

———. (2008t). *S$1.3b standard ICT operating environment tender awarded to oneMeridian*. Retrieved 17 March 2008 from http://www.ida.gov.sg/News%20and%20Events/20080228151049.aspx?getPagetype=20

———. (2008u). *Statistics on Telecom Services for 2008 (Jan–Jun)*. Retrieved 1 August 2008 from http://www.ida.gov.sg/Publications/20080212114723.aspx

———. (2008v). *IDA launches RFP for an OpCo to design, build and operate the active infrastructure of Singapore's Next Gen NBN*. Retrieved 6 August 2008 from http://www.ida.gov.sg/News%20and%20Events/20080407164702.aspx?getPagetype=20

International Telecommunication Union (ITU). (2008). *ICT Eye – Singapore*. Retrieved 1 August 2008 from http://www.itu.int/ITU-D/icteye/DisplayCountry.aspx?countryId=214

Internet Systems Consortium. (2008). *Distribution by Top-level Domain Name by Name Jan 2008.* Retrieved 1 August 2008 from http://www.isc.org/index.pl?/ops/ds/reports/2008-01/dist-byname.php

Media Development Authority (MDA). (2008a). *Singapore on track to build a vibrant Interactive Digital Media Research and Development Eco-system*. Retrieved 28 January 2008 from http://www.mda.gov.sg/wms.www/thenewsdesk.aspx?sid=849

———. (2008b). *Policy and Regulatory Framework for Mobile Broadcasting Services in Singapore*. Retrieved 28 January 2008 from http://www.mda.gov.sg/wms.www/devnpolicies.aspx?sid=152

———. (2008c). *MDA launches new licence framework for IPTV*. Retrieved 28 January 2008 from http://www.mda.gov.sg/wms.www/thenewsdesk.aspx?sid=770

Ministry of Information, Communications, and the Arts (MICA). (2007). *Press Releases — Speech by Dr Vivian Balakrishnan at the Official Opening of Games Convention Asia 2007.* Retrieved 29 January 2008 from http://www.mica.gov.sg/pressroom/press_070906.htm

Singapore Telecommunications (SingTel). (2008). *Bridge Alliance*. Retrieved 28 January 2008 from http://home.singtel.com/consumer/bridge_mobile_alliance/default.asp

Statistics Singapore (SingStat). (2008a). *Key annual indicators*. Retrieved 24 January 2008 from http://www.singstat.gov.sg/stats/keyind.html#keyind

———. (2008b). *Theme on research and development*. Retrieved 28 January 2008 from http://www.singstat.gov.sg/stats/themes/economy/rnd.html

TradeXchange. (2007). *TradeXchange receives strong endorsement from Singapore's trading community*. Retrieved 30 January 2008 from https://www.tradexchange.gov.sg/tradexchange/default.portal?_nfpb=true&_nfls=false&_pageLabel=main_hidden&_type=hidden&_page=hidden1197355703120&_action=view

Wireless Internet Institute (WII). (2008). *Wireless communities best practices awards*. Retrieved 25 January 2008 from http://w2i.com/awards/overview_nominations

ZDNet Asia. (2006a). *S'pore: to get commercial HSDPA*. Retrieved 28 January 2008 from http://www.zdnetasia.com/news/communications/0,39044192,61970637,00.htm

———. (2006b). *Major vendors unit for US$918M tender*. Retrieved 28 January 2008 from http://www.zdnetasia.com/news/business/0,39044229,39310054,00.htm

———. (2007a). *S'pore: Second person charged with Wi-Fi tapping*. Retrieved 25 January 2008 from http://www.zdnetasia.com/news/security/0,39044215,61979500,00.htm

———. (2007b). *Singapore inches towards open source*. Retrieved 28 January 2008 from http://www.zdnetasia.com/insight/specialreports/0,39044853,62034345,00.htm

———. (2007c). *Singapore to grow games talent*. Retrieved 29 January 2008 from http://www.zdnetasia.com/news/business/0,39044229,62031907,00.htm

———. (2007d). *It's game on for S'pore*. Retrieved 29 January 2008 from http://www.zdnetasia.com/news/communications/0,39044192,61976137,00.htm

———. (2008). *Wireless@SG: A cuppa to success?* Retrieved 6 August 2008 from http://www.zdnetasia.com/news/communications/0,39044192,62040719,00.htm