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## **UBIQUITOUS NETWORK SOCIETIES:**

### **THE CASE OF THE REPUBLIC OF SINGAPORE**

## **ACKNOWLEDGEMENTS**

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# 1 INTRODUCTION

In 2004/05, Singapore was selected as one of four SPU case studies to be conducted on the topic of Ubiquitous Network Societies. Although a number of factors went into this decision, the most significant was the clear presence of elements critical for the healthy development of a ubiquitous network society. These include an omnipresent high-speed network (both fixed-line and wireless), applications and services that leverage on their pervasive nature, a nurturing policy and regulatory environment and a population receptive to technology.

At the time of writing this report, 74 per cent of all households in Singapore owned one or more personal computers. Internet access was enjoyed by 65 per cent of all households with two out of three accessing the Internet through broadband. About 83 per cent of all companies in Singapore used a computer with 76 per cent of all companies having Internet access. Mobile phone penetration in Singapore reached a high of 92 per cent in 2004.

## 1.1 Scope and outline of the report

This report aims to provide a concise description of Singapore's development as a ubiquitous network society. Chapter one provides a brief introduction to the country, which is followed by an overview of the ICT sector. Chapter two goes on to describe the institutions and highlight the national ICT strategies, policies and programmes that currently guide the country in its course towards developing a ubiquitous network society.

Chapter three looks at Singapore's fixed and mobile communications networks, the building blocks of a ubiquitous network environment. The chapter describes their genesis; their expansion; their market characteristics; and the policies and strategies that have fostered their development.

Chapter four describes the development and deployment of new technologies, applications and services that leverage increasingly on the ubiquitous nature of communications networks in Singapore. In particular, the chapter will focus on the use of technologies such as RFID across the different sectors of the economy and society. It also goes on to discuss some of the challenges that stand in the way of realizing the vision of a ubiquitous network society. Chapter six focuses on the social aspects of a ubiquitous network society.

## 1.2 Country background

### 1.2.1 Geography and demographics



Singapore has a land area of 699 square kilometers and consists of a group of islands, dominated by a main island, on which the population is concentrated. The country is located just off the southern tip of the Malay Peninsula and is linked to Malaysia, its northern neighbor, by two bridges across the Johore Strait. The closest island grouping of its southern neighbor, Indonesia is located just across the Singapore Strait. Singapore's strategic position at the crossroads of multiple trading routes has defined its unique history and economic development. These particularities coupled with its relatively small size, however, give its population a heightened sense of political and economic isolation and vulnerability. Singapore is a trading and business hub reliant on good relations with its neighbors and trading partners for its economic success and political stability.

In 2004, the population of Singapore was estimated at 4.2 million, of which 3.5 million were Singapore residents. About 77 percent of the country is of Chinese descent, the result of several waves of immigration. The Malay population makes up about 14 percent of the country while another 8 percent is composed of descendants of immigrants from the Indian subcontinent, many of them Tamils from southern India. A core precept of government policy is the equal treatment and

acknowledgment of all cultural and ethnic backgrounds. Chinese (Mandarin), Malay, Tamil, and English are recognized as official languages, with English serving as the predominant idiom in business and government.

### 1.2.2 Human development

In the 2004 United Nations Development Programme's Human Development Index (HDI), Singapore was ranked twenty-fifth among the 177 countries surveyed. The HDI is a calculation based on a variety of factors, including wealth, health, education and quality of life. Singapore has the highest HDI in Southeast Asia and is second only to Japan in Asia.

### 1.2.3 Political economy

With a small domestic market, few natural resources, and a strategic location in Southeast Asia, Singapore developed primarily as a trading nation. It leads Southeast Asia in exports and imports, per capita. According to 2004 World Bank rankings, its gross domestic product (GDP) per capita ranks twenty-ninth in the world, at USD 21'230.

The Singapore government plays an active role in planning and coordinating all major aspects of economic life in the country. It not only proactively works to ensure a favorable climate for business and technology development through numerous and varied programs, it also provides direct financial support for critical industries. This policy is based on the concern that the relatively small size of Singapore's domestic market might not provide sufficient market-based incentives for growth of healthy industries. The government provides direct financial support, predominantly through two methods: the holding of indirect equity stakes—often amounting to controlling interests—in domestic companies; and the provision of grants and subsidies for companies engaging in technology and service innovation. Since 1974, the government has utilized a holding company to channel its capital investments into the Singapore economy. Temasek Holdings Ltd., which is wholly owned by the government, has substantial holdings in most economic sectors, including transportation, energy, banking, shipping, diversified energy, real estate, and ICTs.

## 1.3 ICT market overview

### 1.3.1 Basic indicators

Basic ICT indicators for Singapore are set out in Table 1.1. As in most industrialized nations, the growth of overall telephone density in Singapore has slowed considerably as saturation points are reached. Although mobile subscriptions have increased steadily over the past few years, subscriber growth rates are beginning to slow. At the same time, fixed line numbers have also started a slow decline. The number of mobile subscriptions overtook the number of fixed lines in July 2000.

**Table 1.1: Basic ICT indicators for Singapore**

	1999	2000	2001	2002	2003
Main telephone lines (000s)	1'876	1'946	1'947	1'927	1'889
Main lines per 100 inhabitants	47.49	48.45	47.14	46.29	45.03
Internet users per 100 inhabitants	24.05	32.36	41.15	50.44	50.88
Mobile phone subscribers (000s)	1'630	2'747	2'991	3'312	3'577
Mobile phone subscribers per 100 inhabitants	41.28	68.38	72.42	79.56	85.25
Percentage of homes with a Personal Computer	58.90	61.00	63.90	68.40	73.70

Source: ITU World Telecommunication Indicators Database.

### 1.3.2 Market structure

Singaporeans enjoy easy and widespread access to advanced telecommunication networks and services. This has been made possible due to the country's small size, its considerable wealth and the government's

emphasis on ICT (or “infocomm” in the Singaporean context) sector development. Nevertheless, Singapore’s small market size also acts as a constraint on the level of competition possible at the network facilities level. Singapore generated an estimated USD3.6 billion in telecommunication revenues in 2003.

In April 2000, Singapore liberalized its telecommunications market fully, allowing competition in all telecommunications markets and lifting all limits on direct and indirect foreign equity investment in Singaporean operators. In March 2005, there were 35 Facilities-Based Operator (FBO) licensees that owned their own facilities and more than 700 Service-Based Operator (SBO) licensees that provided telecommunications services over third-party networks. Key FBOs include:

- *Singapore Telecommunications Ltd. (SingTel)* is the country’s incumbent operator. It was corporatized in 1992 and partially privatized in 1993. Temasek Holdings, the Singapore government’s holding company, currently owns 63 per cent of SingTel. In 2004, SingTel continued to dominate the telecommunications sector with a 99 per cent fixed line market share and a 41 per cent share of mobile subscribers. Its competitors, however, have made strong gains in the mobile segment with SingTel’s market share falling by more than 5 per cent in the preceding year. At the end of June 2004, SingTel’s subscriber base included 1.9 million fixed-line subscribers and 1.5 million wireless subscribers. It also boasted a broadband subscriber base of 268,000, or a 60 per cent share of the market.
- *StarHub* is Singapore’s second-largest telecommunications operator, having launched its fixed line and mobile services on 1 April 2000 when the market was liberalized. StarHub’s main shareholders are Singapore Technologies Telemedia (wholly owned by Temasek Holdings), NTT Communications Corporation and Media Corporation of Singapore. Following its merger with Singapore Cable Vision (SCV) in 2001, StarHub acquired a two-way Hybrid Fibre Coaxial (HFC) network that covers 99 per cent of homes in Singapore. At the end of June 2004, the operator had 1 million mobile subscribers, 393,000 residential cable TV customers, 150’000 retail broadband subscribers and 18’000 business subscribers for its fixed services.
- *Mobile One (M1)* is the country’s second mobile licensee. It was formed in 1994 and launched paging and mobile services in April 1997 when SingTel’s monopoly over those markets expired. Its major shareholders include Keppel Telecoms and Singapore Press Holdings Multimedia. At end-June 2004, M1 had 1.1 million mobile subscribers.

## **2 ICT POLICY AND STRATEGY**

### **2.1 Sector reform history**

Singapore has undergone three distinct phases of ICT sector reform. In 1992, Singapore Telecommunications (SingTel) was corporatized. During the process, regulatory and operational functions were separated with the reconstitution of the Telecommunications Authority of Singapore (TAS) as the sector regulator. Reflecting the government’s proactive approach to industry development, the mandate of TAS included not only regulation but also the promotion of the telecommunications industry in Singapore. During the mid to late 1990s, TAS was the agency that implemented the phased introduction of competition through the licensing of services that were progressively liberalized.

During this period, SingTel was operating under a licence that included exclusive rights to provide public basic domestic and international telecom services until 31 March 2007. Although SingTel was also authorized to provide mobile cellular services, the government acted to introduce competition in the mobile cellular sector in May 1995 with the licensing of Mobile One (M1) as the country’s second mobile licensee.

As the pace of liberalization in global telecommunications markets accelerated during the mid-to-late 1990s, however, Singapore felt pressure to keep pace with other East Asian states. In April 1996, the government kicked off a second phase of liberalization, announcing that it would accelerate the start of full competition in the telecommunications sector to April 2002. In the process, SingTel’s exclusivity period was also reduced by seven years, to 1 April 2000, with plans to introduce a measure of limited competition by licensing an additional fixed-line licensee, StarHub.

Before StarHub could enter the market, however, Singapore had embarked on the third phase of liberalization, accelerating the date for full competition from 1 April 2002 to 1 April 2000. On that date, Singapore opened all its telecommunications markets to competition.<sup>1</sup> It was clear that the main impetus for accelerating liberalization was the perception that Singapore risked falling behind its rivals in its effort to become the regional info-communications hub. Hong Kong, China, for example, had already moved forward with full liberalization earlier.

At the same time that the government was moving to open its markets, a number of different government agencies—including TAS, the National Computer Board (NCB)<sup>2</sup>, the Economic Development Board (EDB) and the then Singapore Broadcasting Authority (SBA) developed overlapping responsibilities with regard to ICT promotion, regulation and development. As a result, legislation was tabled to create a single, focused agency that would combine all government promotional and regulatory efforts involving the converging communications industries. The Info-Communications Development Authority of Singapore Act of 1999 officially disbanded TAS and the NCB, creating one new statutory board, the Info-Communications Development Authority (IDA). IDA was legally constituted on 1 December 1999.

## 2.2 Legislation and regulation

### *Telecommunications Act*

The Telecommunications Act of 1999 (The Telecoms Act), passed by Parliament in tandem with the IDA Act, provides much of the legal basis for IDA's actions as industry promoter and market regulator.

The Telecoms Act empowers IDA with the right to provide all telecommunications services within Singapore and gives it the authority to transfer that right to operators through its power to issue licences. IDA also may attach conditions to licences, and it can modify those conditions. In general, there are two categories of licences for the provision of telecommunication services in Singapore: (1) Facilities-Based Operator (FBO) licences and (2) Services-Based Operator (SBO) permits. The FBO licence is always an individual licence, while the SBO may be an individual licence, or for some services, a class licence.<sup>3</sup>

FBO licences are required, in general, for any kind of network infrastructure build-out and operation. This includes international and domestic fixed wire transmission, public cellular mobile networks and switching facilities such as international gateways. Other than for spectrum scarcity reasons, there is no limit on the number of licences that can be issued for services in Singapore. Whenever spectrum limits are an issue, licences may be distributed through a selection or auction process.

Certain SBO licences are distributed on an individual basis such as international simple resale (ISR), virtual private network (VPN) services, Internet access, Internet exchange services and mobile virtual networks (MVNOs). Other services provided over the public switched telephone network and the Internet are subject to a class licence. These would include simple resale of public switched telephony, international callback services, Internet-based voice (VoIP) or international calling card services.

Apart from licensing, the Telecoms Act also gives IDA three general options through which it can implement regulations. IDA can issue:

- “Codes of practice” and “standards of performance” that apply to all licensees offering services;
- “Directions” to specific licensees, instructing them to alter their behavior and giving them a time limit for compliance; and
- “Advisory guidelines”.

For example, the *Code of Practice for Competition in the Provision of Telecommunications Services* was drafted as the blueprint for IDA's regulation of the telecommunications industry in Singapore. It lays the foundation for interconnection and consumer protection as well as applies the principle of asymmetrical regulation to ensure a level playing field.

IDA also has the authority to allocate radiocommunications spectrum for both public sector and private sector uses. IDA collaborates with the Media Development Authority (MDA), the broadcast regulator, for the latter to assign frequencies to broadcasters after IDA has decided on the national spectrum allocation for broadcasting service and cleared the technical operation for broadcast transmitters.



Beyond policy and regulation, IDA is also tasked to promote the development of info-communications within Singapore. In general, its promotional activities can be grouped into three categories: (1) Outreach to residents and companies to promote the use of information and networking technologies; (2) promotion and development of Singapore's info-communications industry itself; and (3) outreach beyond Singapore's borders to stimulate investment and provide an outlet for exports. IDA pursues these, in part, through organized and well-funded programs to proactively subsidize and sponsor the development and adoption of new technologies, applications, services and business models. Initiatives and promotional activities range from technology fairs and expositions to providing seed money for research and development efforts.

#### *Electronic Transactions Act*

The Electronic Transactions Act was enacted in July 1998 to create the legislative framework for electronic transactions in Singapore. It provides for the legal recognition and usage of electronic signatures and electronic records, and also covers the duties of certification authorities, duties of subscribers and the regulation of certification authorities. The Act follows closely the UNCITRAL Model Law on Electronic Commerce, which sets the framework for electronic laws in many countries. It addresses the following issues:

- *Commercial code for e-commerce transactions*

The Act defines the rights and obligations of the transacting parties. It also addresses the legal aspects of electronic contracts, use of digital signatures and concerns for authentication and non-repudiation.

- *Use of electronic applications for public sector*

The Act contains an omnibus provision through which government departments and statutory boards can accept electronic filings without having to amend their respective Acts. It also allows public bodies to issue permits and licences electronically.

- *Liability of network service providers*

Realizing that it is impractical for network service providers to check all the content to which they provide access, the Act specifies that network service providers will not be subject to criminal or civil liability for such third-party material, in relation to which they are merely the host.

- *Provision for a Public Key Infrastructure (PKI)*

Singapore has been developing a Public Key Infrastructure as a foundation for a trusted and secure environment in electronic commerce. In line with the PKI development, the Act provides for the appointment of a Controller of Certification Authorities (CCA) to enable regulations to be made for the licensing of certification authorities (CAs), including recognition of foreign CAs.

#### *Computer Misuse Act*

The amended Computer Misuse Act was enacted in June 1998 to deal with new potential abuses of computer systems in a networked environment. The amended Act takes a more nuanced approach to provide for enhanced penalties proportionate to the different levels of potential and actual harm caused. It also addresses new potential computer abuses such as denial or interruption of computer services and unauthorized disclosure of access codes.

### **2.3 National strategies**

The government of Singapore has traditionally taken an active role in the development of the nation's ICT sector. From the early 80s, the Singapore government has methodically designed and implemented a succession of national plans and strategies to guide the nation on its ICT development path (see Box 2.1).

### **Box 2.1: National strategies**

*1980 to the present*

Reflective of the changing technological, business and social climate, Singapore has progressed through five distinct national IT plans over 25 years.

**National Computerisation Plan** (1980-1985). One of the key objectives of the National Computerisation Plan was to computerize the major functions in every government ministry. Directed at improving public administration through the effective use of IT, the effort focused on automating traditional work functions, reducing paperwork and escalating the deployment of IT in the Public Service.

**National IT Plan** (1986-1991). The focus then shifted to the provision of one-stop services through cross-agency linkages. A significant number of public services were developed in the direction of the 'One-Stop, Non-Stop' strategy by using IT to automate and integrate traditional manual administrative processes.

**IT2000** (1992-1999). The IT2000 masterplan was launched to position Singapore as a global IT hub. Building on the National IT Plan, the expanded focus included construction of a nationwide broadband network, the development of common network services (e.g. directories, billing, security authentication), the forging of international alliances with industry leaders in Japan, Europe and the US and the establishment of a policy and legal framework on issues such as intellectual property rights and computer crime. In the public sector, the Internet was introduced as a new delivery channel providing both information and transaction-based services to the public.

**Infocomm 21** (2000-2003). Spurred by the convergence of telecoms and IT, the Infocomm 21 blueprint was launched in 2000 to develop Singapore into a global infocomm capital with a thriving and prosperous e-economy and a pervasive and infocomm-savvy e-society. The plan involved multiple strategic thrusts that included: developing the ICT industry, promoting e-business practices and applications, delivering more government services online, expanding access to ICT to the population, nurturing ICT talent and creating a pro-competitive ICT policy environment.

**Connected Singapore** (2003- present). The current blueprint continues to build on the Infocomm 21 plan but with a different focus. It sees infocomm as a key enabler, to create new business opportunities, consumer value and cultural experiences.

Source: Adapted from IDA

In 2003, IDA launched its current national strategy, "Connected Singapore". Essentially a re-visioning exercise of the previous national strategy, the current strategy takes cognizance of the need for Singapore to develop new sources of growth, including new areas involving creative inputs, like design and the arts. Instead of developing infocomm for its own sake, the vision sees infocomm as a key enabler, aimed at increasing the productivity and efficiency of individuals, organizations and businesses. Under this vision, infocomm technology is also regarded as a catalyst for the creation of new business opportunities, consumer value and cultural experiences.

IDA currently implements a wide range of programmes under four key strategies to bring about the realization of the Connected Singapore vision:

- *Infocomm for Connectivity, Creativity and Collaboration* aims to place infocomm products and services into the hands of everyone by developing an infocomm infrastructure for pervasive and secure access; encouraging the development and use of infocomm applications and services; and promoting infocomm literacy.
- *Digital Exchange* aims to develop Singapore as a leading global digital distribution and trading centre. IDA currently focuses on developing end-to-end infrastructure that integrates the processes of digital production, management, localization, archival and secure distribution. This infrastructure in turn is aimed at supporting a wide range of businesses such as online gaming, digital publishing and software distribution.
- *Engine of Growth* aims to grow new economic activities and job creation in infocomm by focusing on the development of five key industry clusters: value added mobile services, infrastructure for wireless and wireless networks, multimedia processing and management, web services and portals and security and trust infrastructure.

- *Agent for Change* aims to help businesses and government agencies use infocomm to achieve higher levels of efficiency in delivering their products. This involves reengineering key business clusters and government services through deploying common infrastructure and standards, redesigning business processes and encouraging the use of technologies and applications that improve linkages between the government, companies and consumers.

With the 3-year Connected Singapore lifecycle ending in 2006, IDA is currently embarking on a new strategic visioning and planning exercise to develop the next national strategy termed iN2015.

It is useful to note that despite the ostensible differences seen in the couching of each successive national strategy, the Singapore government's efforts to promote infocomm development have been characterized by progressive evolution as opposed to disruptive revolution. To a large extent national strategies preserve continuity in infocomm development while serving as a catalyst for further renewal. A large number of established programmes continue from one national strategy to the next, as do established institutional structures. Institutional reorganization and the lapsing of established programmes are not generally timed to match the unveiling of a new national strategy.

At the same time, it is also important to realize that the introduction of each national strategy is not designed to be static nor does it exist as an exclusive self-contained policy guide. On a periodic basis, complementary strategies and policies are introduced during the lifespan of a national strategy to reinforce, refresh, and occasionally refocus its basic tenets.

## 2.4 Infocomm Technology Roadmap (ITR)

Alongside the development of national ICT strategies, IDA also embarks on periodic technology visioning exercises in order to identify key technology enablers and technology market trends. Referred to as Infocomm Technology Roadmaps (ITR), IDA is currently in its 5<sup>th</sup> cycle, having released its 10-year Infocomm Technology Roadmap 5 (ITR5) in March 2005 (see Box 2.2).

### Box 2.2: Highlights from Infocomm Technology Roadmap 5 (ITR5)

ITR5 forecasts the following broad trends:

#### 1. *The computing wave*

By 2015, the PC as we know it today will 'disappear' and computer mainframes will be accessible via revolutionized devices infused with nanotechnology. Computers will be so small that they will be embedded in everyday devices, and computing will be further revolutionized by innovations including Grid Computing, Peer-to-Peer technology, Service-Orientated Architecture such as Web Services, and software agent technologies.

#### 2. *The communications wave*

Experts anticipate that the world will be covered by optical fiber providing an almost unlimited capacity to transport data anywhere around the world. Its low-cost deployment will result in unlimited bandwidth subscription, and this fabric of network connectivity will mean broadband will be available everywhere where the service is needed. It is also predicted that Internet Protocol (IP) will become the unifying platform, providing high levels of end-to-end quality of service and security.

#### 3. *The sentient wave*

The confluence of the first two waves will result in intelligent devices that can sense and interact with one another. Countries will exploit these to build nationwide sensor networks, like chemical and biosensors, to operate around the clock, detecting a wide range of potential homeland threats. Smart systems will also be deployed for various purposes. For example, smart systems will be set up to advance eldercare, sensing and reminding elderly patients at home to take their medication.

Source: IDA

## 2.5 “Wired with Wireless” programme

Initiated in October 2000 under the Infocomm 21 plan and reprised by the Connected Singapore blueprint, IDA's Wired with Wireless programme is the organization's main launch pad for major initiatives to develop the country's wireless value chain – from infrastructure to content.

Under the programme, IDA collaborates with industry to identify, develop and launch key projects with industry-wide impact. This collaboration largely takes the form of pilot and trial projects that are designed to foster thought leadership; market access development; manpower and technology development; infrastructure & product development; and industry and consumer adoption in five key areas: machine to machine communications (M2M), wireless multimedia and messaging, location based services, mobile commerce and wireless enterprise. Key ongoing initiatives under the programme include the following:

In October 2000, the *Pilot and Trial Hotspots (PATH) Initiative* was launched as a SGD 78 million government grant programme aimed at accelerating the development of innovative infocomm infrastructure, applications and products. The programme supports projects proposed by companies and organizations that are registered and operational within Singapore. Originally targeted at developing the five key wireless areas listed above, this initiative was subsequently expanded to include other innovative infocomm technology areas prioritized by IDA.

Under the PATH initiative, IDA uses a *Call for Collaboration (CFC)* mechanism to promote industry partnerships in the development of infocomm solutions and applications. Under this process, CFCs are issued to interested industry players for proposals to collaborate with one another in the development of pilot and trial projects that can benefit the entire industry as a whole. IDA support in the form of grants and other incentives are used as an enticement. The list of Wired with Wireless CFCs that have been issued include:

- Mobile Payment Systems CFC
- Mobile Workforce Solutions CFC
- Wireless Java Solutions CFC
- Pervasive Wireless Access CFC
- Location-Based Services CFC
- Smart Airport & Passenger Travel CFC

Some of the applications and services that have been developed as a result of these CFCs are described in greater detail in the chapters below.

Besides facilitating infocomm companies to develop and implement their solutions through pilots and trials, IDA also has a Market Development (MADE) initiative that was set up to help accelerate a company's foray into potential markets. The initiative supports market research activities such as test marketing, as well as showcases and promotes innovative products through joint promotional activities.

In keeping with the leadership role played by the government in industry development, IDA has also set up a *Wireless Technology Alliance (WTA)* to encourage the transfer of wireless technology skills and expertise among local wireless industry players. Designed as an industry forum, its goal is to match make industry players that occupy different tiers on the wireless value chain. For example, the partnerships that the initiative has brokered include the establishment of the Java Wireless Competency Centre, which brings together IDA, Sun Microsystems and the Institute for Infocomm Research for the purpose of Java research and training.

Reflecting the holistic approach to wireless development, the Wired with Wireless programme also incorporates elements of skills development and awareness building. With the aim of seeding talent and increasing exposure to the wireless industry among the youth in Singapore, IDA has facilitated the setting up of *Mobile Clubs* in secondary schools and junior colleges. Mobile Clubs are the product of partnerships between interested schools and a wireless industry sponsor(s) who works with the school to provide wireless training and industry exposure. Mobile club activities may include the development of basic logos and ring tones for mobile phones. More advanced students may be given an introduction to Wireless Access Protocol (WAP) and Java tools to program their own games and applications. Currently mobile clubs have been established in five schools on the island.

### 3 BUILDING BLOCKS OF A UBIQUITOUS NETWORK

#### 3.1 Fixed-line broadband

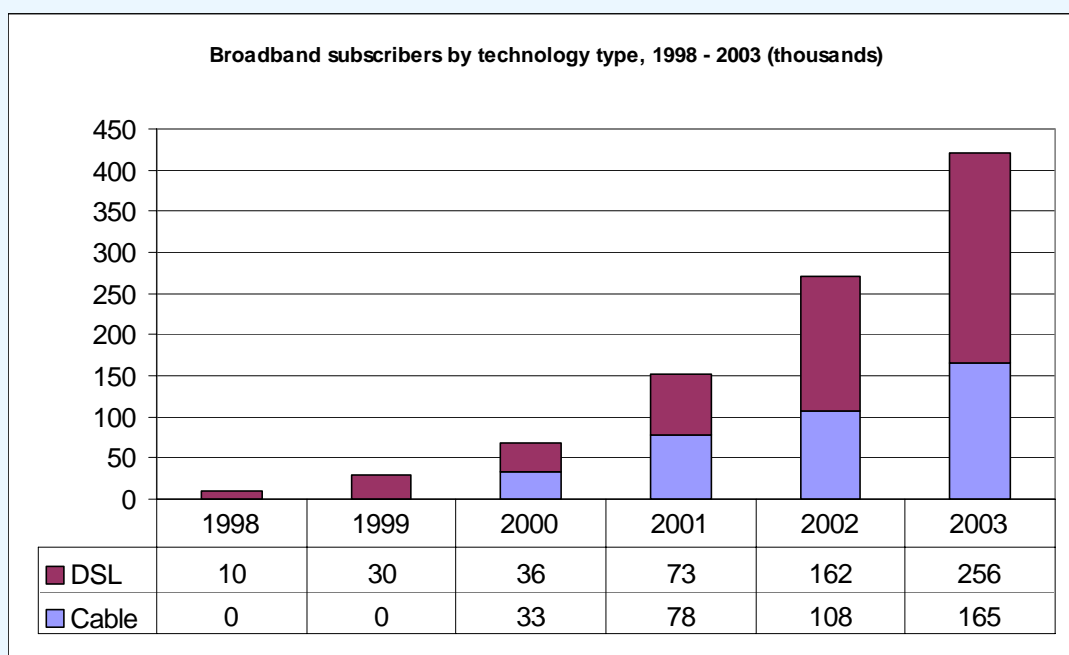
In 1992, under the IT2000 master plan, planning began for the building of a national information infrastructure (NII) to support the applications it proposed. The construction of a high-speed nationwide broadband network was envisioned as the cornerstone of the NII. In 1996, 1-Net Singapore, an industry consortium led predominantly by government-linked companies, was formed to build, own and operate the core Asynchronous Transfer Mode (ATM) backbone network for Singapore ONE. Singapore ONE was to comprise two distinct but integrated levels. The first was a broadband infrastructure level of high-capacity networks and switches. The second was a level of advanced applications and services that took advantage of the infrastructure's high-speed and high-capacity capabilities. Construction on the 622Mbit/s nationwide fiber optic network lasted till June 1998 when it was commercially launched, making Singapore the first in the world to have a nationwide broadband network covering 99 per cent of the entire country.

Retail residential broadband access is now mainly supplied through three providers: SingTel, using ADSL technology, StarHub, using cable modem technology and Pacific Internet, a local ISP that uses a combination of SingTel's and StarHub's unbundled last mile infrastructure (see Figure 3.1). According to IDA statistics, at the end of 2004 Singapore had 512'400 broadband subscribers and a household broadband penetration rate of 42.3 per cent.

Singapore's model of broadband promotion and growth has attracted a mix of admiration and criticism. An absence of effective competition and the lack of compelling broadband content resulted in low adoption rates in the first few years following its launch. To a large extent, government user subsidies played a much larger role in boosting adoption in the early years than commercial demand. Despite initial setbacks, however, Singapore ONE nevertheless served successfully as the centerpiece of the country's commitment to technological advancement, perking industry interest in the sector. Over the past few years, with more competition, lower prices and a wider range of services, the Singapore ONE has achieved the results hoped for by its original architects, albeit a little later than envisaged. The construction of the Singapore ONE nationwide broadband network was clearly an enterprise ahead of its time.

**Figure 3.1: Broadband in Singapore**

*Broadband subscribers by technology type, 1998 – 2003 (thousands)*



Source: ITU Telecommunication Indicators Database

## **3.2 Wireless broadband**

### **3.2.1 Wireless broadband access (WBA)**

With close to complete fixed-line broadband network coverage in Singapore, the option of using wireless technologies to deliver fixed-wireless broadband access has not been commercially popular among the major operators.<sup>4</sup> Nevertheless, in a renewed bid to introduce greater facilities based competition into the broadband market segment, IDA announced the intended release of spectrum for wireless broadband access (WBA) in the 2.3 GHz and 2.5 GHz frequency bands, which were earlier earmarked for technology and business model trials in Singapore. IDA will divide the spectrum into 25 lots, with most companies allowed to bid for up to the six lots that ensure island wide coverage. Market incumbents StarHub and SingTel, however, will be limited to only four lots each, in an attempt to encourage new market entrants. Successful bidders for the 2.5GHz band will have to offer public wireless broadband services within 18 months of the licence being issued, while those working on the 2.3GHz band will be given 36 months due to the limited amount of equipment

In order to preserve operator flexibility, IDA has announced that it will not impose requirements on carrier technology or provider interoperability. Unlike 3G licensees, mobile broadband providers can also opt to roll out services in a limited area rather than nationwide. Depending on the technology deployed by operators, WBA services may eventually be accessible from either fixed points or mobile devices. But due to a commitment IDA made during the 3G spectrum auctions, successful bidders of the WBA spectrum will not be allowed to deploy any technologies belonging to the IMT2000 family of 3G standards prior to 1 January 2006. Acknowledging that the line between 3G services and mobile WBA services are blurred, IDA employs a “fixed” versus “mobile” distinction as the key differentiating factor between the two services. As a result, WBA operators will not be allowed to offer mobile or restricted mobile services at vehicular speeds above 10 km/hour before 1 January 2006, a speed limit based on definitions introduced by an ITU-R recommendation on IMT-2000 technologies.<sup>5</sup> After 31 December 2005, subject to licensing requirements, WBA operators will be allowed to offer any type of broadband wireless service, fixed and/or mobile.

Industry response to the announcement has been mixed with potential new market entrants applauding the decision to limit spectrum allocated to the market incumbents. Nevertheless, operators have also raised concerns regarding the timing of the auctions. With the emergence of different technologies offering different capabilities and harnessing different frequencies, some carriers are waiting for a single global standard to emerge.

One possible standard that is currently being monitored by IDA and operators is WiMax, based on IEEE's 802.16 standard, which many expect to be largely deployed in the 3.5GHz band. IDA is currently studying the possibility of issuing 3.5GHz spectrum for the provision of WBA services. Currently, the 3.5GHz band is heavily used in Singapore for fixed-satellite services.

As a whole, industry interest in providing WBA services in Singapore appears strong with interested operators having commenced WBA trials. M1, for example, announced in November 2004 that it had started technical trials of wireless broadband systems that allow access speeds of more than 1Mbps. These include technologies based on FDD (paired spectrum), TDD and UMTS TDD.

### **3.2.2 Wireless Local Area Networks (WLAN)**

In 2004, there were more than 8 public WLAN service providers that extended service coverage to more than 600 public hotspots in Singapore. While this represents a WLAN density of one hotspot per square kilometer in Singapore, hotspot coverage is concentrated largely in commercial areas that attract high volumes of human traffic such as in the airport and in shopping malls.

Currently, SingTel boasts coverage of more than 200 hotspots across the island. These are mostly centered on popular food and beverage outlets such as Starbucks and Burger King, as well as a variety of country and community clubs. Hotspot access is available to subscribers on a pre and post-paid basis. StarHub entered the WLAN hotspot market with the launch of its largest wireless LAN hotspot at the Suntec City Convention Centre, covering 180,000 square meters. StarHub also currently provides wireless coverage in more than 300 hotspots scattered over the island. In addition to operator-managed hotspots, non-telecommunications related

companies have also hosted WLAN hotspots to complement their businesses. McDonalds restaurants, for example, have set up hotspots in over 120 of locations in Singapore in partnership with wireless operators.

Operator figures suggest that the use of WLAN hotspots is increasing. In 2004, for example, SingTel reported a doubling in the number of WLAN minutes used by its subscribers over the previous year. The operator sees more than a hundred thousand minutes of use on average for its WLAN hotspot service every month.

A number of factors have contributed to this growth. On the part of the operators, increases in WLAN hotspot coverage and the introduction of innovative pricing plans that bundle WLAN hotspot services together with residential fixed-line broadband subscriptions and mobile data subscriptions have led to increase hotspot use. More significantly, increase usage also has to be attributed to the increasing popularity of devices that are WLAN enabled. WLAN enabled laptops and PDAs are now increasingly seen as the industry norm.

#### *Spectrum policy*

In order to increase the deployment of WLAN networks and boost coverage of WLAN networks, IDA continues to pursue a favorable licence-exempt spectrum policy. In Singapore, licence-exempt WLAN services can be provided in the 2.4GHz (2400 - 2483.5MHz) and 5GHz (5150-5250 MHz and 5725-5850 MHz) bands. In February 2004, IDA increased the bandwidth for WLAN in the 5GHz band by making the adjacent 5250-5350 MHz frequency band available for WLAN deployment with a power limit of 200 mW. In October 2004, it increased power output limitations for the 2.4GHz band from 100mW to 200mW in order to allow operators to achieve wider WLAN coverage with less equipment.

#### *Wireless network interworking*

In its efforts to support the development of wireless services, applications and technologies, IDA has taken a particular interest in the area of wireless network interworking, a term used to describe seamless user connectivity across multi-operator, multi-platform wireless and wired networks. Currently, different operators provide different services on different fixed-line and wireless networks which are based in turn on different technical standards. This has resulted in multiple but isolated pockets of connectivity. As a result, consumers end up having to subscribe to different operators, receiving different bills, while grappling with the inconvenience of switching networks, such as remembering different passwords for different networks.

Launched in March 2003 under the Wired with Wireless programme, the Wireless Interworking Initiative (WII) is a joint collaboration between IDA and Intel to develop an open and standards-based architecture for cross-operator network roaming, via the interworking of public WLANs, Wireless Wide Area Networks (WWAN) and Wide Area Networks (WAN).<sup>6</sup> The initiative involves two main components, an interworking study and a series of lab tests.

To date, the WII has released its Public WLAN Interworking Study - Validation Report. This document describes the results of the Interoperability Lab Test which validates the Public WLAN Interworking Reference Architecture developed under the interworking study. It highlights the issues observed across the different PWLAN authentication methods and presents an assessment of these methods. The document also describes a set of recommendations and an architectural blueprint for deploying open, standards-based Public WLAN hotspots (see Box 3.1).<sup>7</sup>

#### **Box 3.1: Wi-Fi roaming services in Singapore public libraries**

##### *Read & Roam @ Library*

Since March 2004, public libraries in Singapore have offered multi-operator roaming wireless broadband access to their users. The service forms part of a larger arrangement that allows roaming between an alliance of several wireless operators as well as ten institutes of higher learning. Using the open public WLAN architecture validated under the IDA-Intel Wireless Interworking Initiative, the roaming service allows users to log on to WLAN hotspots provided by participating operators just by using the login IDs issued to them by their respective operators.

Source: <http://www.icellnetwork.com>

### 3.3 Mobile

In 1973, tone-paging services were first launched in Singapore as a precursor to the introduction of mobile services. Mobile technology made its debut in Singapore in 1977 with the launch of the country's first mobile telephone system designed to support the use of car phones. This was then followed by the introduction of a cellular mobile radio system that operated on the Advanced Mobile Phone System (AMPS) standard in 1988 by SingTel. A second analogue cellular system based on the Extended Total Access Communication System (ETACs) was then added in 1991. In 1994, digital mobile phone services based on the GSM standard were launched in the 900 MHz frequency band. The next year, a second GSM network was launched in the 1800 MHz frequency band.

Partial liberalization of the domestic mobile and paging markets was introduced in 1997 with the entry of Mobile One (M1) into the market as a competitor to SingTel. M1 was licensed to provide mobile services over both GSM and CDMA. In 2001, however, M1 migrated its approximately 50'000 CDMA users to its GSM network. In April 2000, StarHub joined M1 and SingTel in the mobile market, bringing the number of mobile operators in the market to three (see Table 3.1).

**Table 3.1: Mobile technologies deployed in Singapore**  
*Services provided by mobile operators*

Operator	2G (Date of launch)	2.5G (Date of launch)	3G (Date of launch)
Mobile One	GSM 900/1800 (April 1997)	GPRS (July 2001)	WCDMA (February 2005)
SingTel	GSM 900/1800 (March 1994)	GPRS/HSCSD (September 2001)	WCDMA (February 2005)
StarHub	GSM 1800 (April 2000)	GPRS (October 2001)	WCDMA (Proposed launch - 1 <sup>st</sup> half of 2005)

Source: Operator data

#### *Mobile penetration*

Competition and deregulation accompanied by falling prices accelerated the take up of mobile services in the latter half of the 90s. Since 2000, the number of mobile subscribers has outnumbered the number of fixed-line subscribers (see Figure 3.2). In January 2005, there were 3'899'600 mobile subscribers in the country, resulting a mobile penetration rate of 92 per cent.

Paging services (numeric and messaging) have suffered greatly as a result of the increased popularity of mobile services. From a peak of 43.9 per cent in May 1998, paging penetration rates fell to a low of 5.6 per cent in September 2003 when M1 announced the closure of its paging business by the year-end. Currently only SingTel continues to provide paging services.

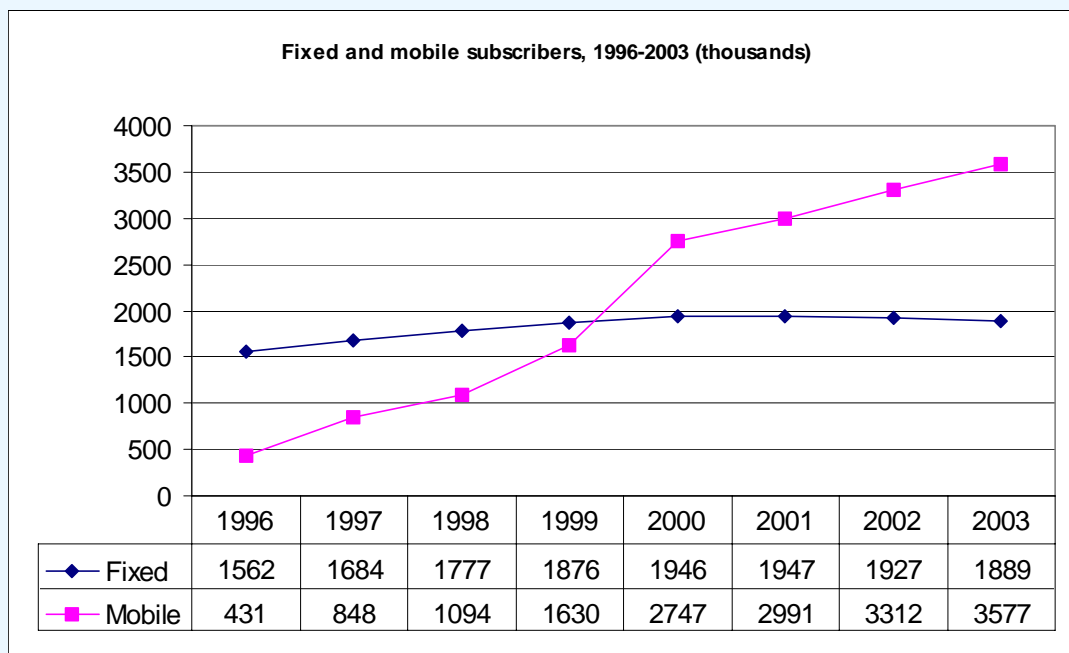
#### *Mobile handsets*

Despite the small mobile subscriber base of around 3.8 million mobile subscribers nationwide, the volume of handset sales in Singapore has been substantial. In 2004, 1.73 million mobile handsets were sold, a rise of 14 per cent over the past year. According to market research estimates, Singaporean mobile subscribers replace their mobile handsets on average once every two years. Beyond a desire to possess the latest and the best, analysts point to handset subsidies (which typically accompany post-paid subscriptions of two years), the constant introduction of new models and sharp reductions in handset prices as key drivers of constant handset replacement.



**Figure 3.2: Mobile penetration in Singapore (1996 - 2004)**

*Mobile overtakes fixed in Singapore*



Source: ITU Telecommunication Indicators Database

This has important implications on the eventual growth of new applications and services. With short handset replacement cycles guaranteeing the use of the latest handset technologies, new applications and services can be more easily absorbed by subscribers.

#### *Policy and regulation*

Mobile number portability is mandated in Singapore. IDA has prohibited operators from charging for number portability since August 2003 and has mandated number portability for Short Messaging Systems (SMS) since October 2003.

In September 2003, IDA introduced a revised allocation procedure for numbering resources. In place of allocating sequential numbers on a first-come-first-served approach, mobile operators were allowed to bid for the number levels they wished to acquire. IDA hopes to achieve greater efficiency, objectivity and transparency by using this method. It stands to reason that as operators are made to pay for the number ranges they seek, they will be more motivated to manage their numbers in a more efficient manner.

There are currently no Mobile Virtual Network Operators (MVNOs) in Singapore. UK mobile provider Virgin Mobile attempted to enter the market as an MVNO in 2001. However, due to a low take-up of its services, it ended its venture within a year.

#### **3.3.1 Mobile data and Internet access**

Despite operator efforts to the contrary, the take up of mobile data and Internet access services have been lackluster in Singapore with the exception of SMS messaging. Industry observers point to a number of factors that are likely to be behind the low initial take-up: slow transmission speeds and a general lack of content adapted for mobile use as well high fixed-line Internet and broadband penetration rates and short commuting distances make surfing from the home and the office a preferred choice for most consumers. Currently, the percentage of mobile data and Internet users as a percentage of total mobile subscribers is estimated by IDA to be at 14.6 per cent<sup>8</sup>.

Despite the slow initial take-up, the country's three mobile operators have continued to aggressively promote the development and use of mobile data and Internet access. Given high mobile penetration rates, operators have acknowledged that the scope for quantitative growth to be eked out of the domestic market is severely

limited. In response to the market environment, the operators have instead focused on qualitative growth through the promotion of mobile data and Internet access services. For 2003, the three mobile operators reported monthly ARPUs levels of around SGD 15 to 20 for pre-paid customers and SGD 60 to 75 for post-paid customers. Non-voice services accounted for 15 to 18 per cent of ARPU during the same period, an increase of around 1 to 2 per cent over the last year for all operators.

#### *Short Messaging Services (SMS) and Multimedia Messaging Services (MMS)*

Since its introduction, Short Messaging Services (SMS) have been an immensely popular communication tool for Singaporean mobile users, particularly among the youth. All operators provide SMS services.<sup>9</sup>

In December 2004, 692 million SMS messages were sent, an average of 22 million SMS messages sent daily. In 2004, StarHub reported that each subscriber sent an average of 113 SMS messages each month. Low SMS pricing has been cited a key driver of SMS use in Singapore. In 2004, it cost around SGD0.10 to send an SMS message with a pre-paid subscription and SGD0.05 with a post-paid subscription. Popular subscription plans often bundle the sending of a number of free SMS messages into their pricing.

In March 2002, M1 became the first in Singapore to introduce multimedia messaging services (MMS) with other operators following quickly behind.<sup>10</sup> According to industry estimates, around 12 per cent of Singapore's mobile phone subscribers were active MMS users in 2004. For the large part, operators have cited the increased ownership of MMS capable handsets with built in cameras. Thus far, the usage of MMS has been largely confined to user-created content such as digital images taken on camera-enabled handsets. With picture quality improving rapidly, operators have seen a corresponding increase in MMS usage.

#### *Wireless Access Protocol (WAP)*

Mobile Internet access based on Wireless Access Protocol (WAP) was initiated in the first half of 2000. All operators launched their own WAP portals during that period, offering content such as online banking, stock inquiries, news, and sports results.

#### *2.5G*

At the same time, mobile operators in Singapore were also developing faster mobile data services to boost GSM's normal data speeds of 9.6 kbit/s. In 1999, M1 introduced the island's first "high-speed" mobile data offering using proprietary technology to achieve speeds of 14.4 kbit/s. In November 2000, M1 launched a pilot higher-speed offering using General Packet Radio Service (GPRS) technology. The following month the operator subsequently became the first in the world to introduce GPRS roaming when it launched the service between itself and PCCW CSL in Hong Kong, China. SingTel currently offers a time-based mobile data service at speeds of up to 38.4kbit/s using High Speed Circuit Switched Data (HSCSD). It also offers a higher speed volume-based service using GPRS that claims transmission speeds of up to 44 kbit/s. StarHub provides a similar GPRS service.

To date, none of the operators have added higher speed 2.5G technologies to their service offerings, having chosen instead to concentrate on the deployment of their 3G networks. In October 2002, StarHub had to abandon its initial plans to deploy Enhanced Data rate for GSM Evolution (EDGE) technology when it failed to obtain a waiver from IDA's December 2004 deadline for nationwide 3G deployment. In its representations, StarHub argued that by allowing them to deploy of EDGE in fulfillment of their 3G rollout obligations, consumers would be given the choice of an alternative cost-effective high-speed service. In their view, the deployment of EDGE would have been a logical incremental step on the evolutionary path towards 3G deployment.

#### *Market analysis*

The take-up of mobile data and Internet access in Singapore thus far appears to be lukewarm in comparison to Japan's popular I-mode service. Nevertheless, operators have continued to take great pains to boost mobile data and Internet access adoption. Given the fact that the vast majority of subscriber handsets now are GPRS enabled and that the migration of 2G users to 3G networks will take place over a period of time, operators have still found it necessary to concentrate also on promoting GPRS use. Promotional activities have typically involved a multi-pronged approach of price reductions, increased content and product

bundling. In order to increase returns from data services, SingTel, for example, has bundled GPRS, ADSL broadband and Wi-Fi hotspot access services in one package.

Over the past year, there has been some cause for optimism. Operators point toward two trends that indicate that mobile data and Internet access use is on the rise: an increase in GPRS and MMS traffic and an increase in the contribution of mobile data services to monthly mobile ARPU. For example, GPRS traffic on StarHub's network doubled from 288 Gbytes in December 2003 to 589 Gbytes in December 2004. Similarly, in June 2004, SingTel reported that mobile data contributed 18 per cent of its mobile ARPU as compared to 16 per cent a year ago. As a whole, operators have credited the provision of differentiated content and lifestyle applications and the introduction of an increased range of GPRS enabled handsets onto the market with colour screens and integrated cameras as key factors behind the increasing popularity of mobile data and Internet access use.

### **3.3.2 Third-generation (3G) mobile**

#### *Spectrum rights*

In October 2000, IDA announced its procedure for awarding 3G mobile licences, allocating frequencies in the 1900 MHz and 2100 MHz bands for 3G services.<sup>11</sup> Despite industry expectations of a beauty contest, an auction system was used to award four 3G licences. A reserve price was set at SGD 100 million for a licence duration of 20 years. As an incentive for operators to invest in 3G spectrum and the deployment of 3G networks, the government undertook, as part of the auction terms, not to grant any further spectrum rights for 3G mobile communication services before 1 January 2006.

Before the auction date, however, IDA was forced to drastically alter its 3G licensing strategy. At the last minute, the only outside bidder, Sunday Communications Ltd. of Hong Kong, China withdrew from the auction, having failed to submit the required bank guarantee. That left only three bidders, the incumbent Singaporean 2G licensees, as contenders for the licences, negating the need for an auction. As a result, IDA announced on 11 April 2001 that it would simply allow the incumbents to receive the 3G licences in return for a payment of the reserve price.

Industry observers blamed the outcome on the small domestic mobile market - Singapore has only four million residents - and on the worldwide collapse in investor sentiment towards telecommunications and 3G during that period. On the positive side, however, the relatively low licence fee paid coupled with the small geographic area of the country have resulted in lower capital costs for 3G network build-outs in Singapore, particularly in comparison to the capital costs that many major mobile operators have incurred in Europe. As a point of comparison, SingTel's 3G network was built by Ericsson at a cost of SGD 220 million.

It is also interesting to note that the resale of the spectrum rights for 3G licences is allowed, subject to regulatory approval from IDA. Transferred or resold spectrum, however, can only be used for 3G services. IDA approval is subject to an assessment to ensure that the resale is made in accordance with the relevant provisions in the Telecom Competition Code of Practice governing the transfer of licences and consolidation of licensees.

#### *Network deployment*

Under the terms of the licences issued, the deadline for nationwide 3G network deployment was set initially for 31 December 2003. This deadline was subsequently postponed to 31 December 2004 as a result of worldwide delays experienced in obtaining the necessary handsets and equipment. Although operators were given a choice of what standards to use - typically Wideband CDMA (WCDMA) or CDMA 2000 - a number of constraints limited operator choice in practice. The particular spectrum bands allocated for 3G services as well as the practicality of following the evolutionary path set for GSM operators resulted in all 3G licensees rolling out networks employing the WCDMA protocol.

On the expiry of the deadline, IDA announced that all three licences had successfully met licence requirements for network rollout. In its evaluation, IDA used the measurement criteria of at least 95% of street-level 3G radio coverage on the island using a signal strength that is greater or equals to minus 100dBm. Over 200,000 signal strength samples were taken from each operator's networks.

### *Commercial launch*

On 18 February 2005, M1 became the first operator to commercially launch 3G services in Singapore under the straightforward brand name "M1 3G". M1 was followed in quick succession by SingTel who commercially launched its 3G offering, dubbed "3logy", the following week on 23 February 2005. StarHub announced plans to commercially launch its 3G services in the first half of 2005.

3G services were marketed aggressively on launch. M1 announced 3G video call airtime charges of SGD 0.40 a minute for incoming and outgoing calls. This was subsequently reduced to SGD 0.15 a minute a month later. At the time of launch, M1 had not revealed charges for 3G data downloads, which were free for its 3G users until the end of March 2005. To further encourage migration to its 3G services, M1 customers were allowed to upgrade to 3G on their current tariff plans by purchasing a 3G handset and switching to a 3G SIM card. It also announced that its 3G users would be able to make international video calls to 12 countries and enjoy 3G roaming in seven countries, with that list expanding over time. A week later, SingTel announced that local video calls would be charged at the same rates as local mobile voice calls - about SGD0.15 a minute depending on the subscription plan. SingTel announced that it would also treat video call airtime as part of subscribers' free bundled airtime. On the data front, SingTel has priced 3G download charges at 30 per cent less than that charged for the slower GPRS service. Downloading a megabyte of data via 3G costs SGD3.50, compared to SGD5 via GPRS. Alongside, SingTel also introduced an unlimited usage data plan at SGD199 a month. Data charges for subscribers not on an unlimited data plan are capped at SGD299 a month.

To lure 3G subscribers, M1 and SingTel have offered most of their 3G content free during the launch period. Content already on offer include movie trailers, MP3 downloads, music videos and 'live' streaming of news feeds from local free-to-air channel Channel News Asia.

### *Market analysis*

At the end of February 2005, two weeks after the commercial launch of its 3G services, SingTel claimed to have 2000 subscribers subscribed to its 3G services. Conservative industry projections predict that by year-end, the total number of 3G subscribers island wide will likely top 110'000. Hong Kong, China, with a larger market of 7 million inhabitants, counted 220'000 3G subscribers in March 2005, slightly more than one year after the commercial launch of 3G services there.

With its small market and high mobile penetration rate, Singaporean operators are likely to end up cannibalizing their existing 2G subscriber base to fuel growth in 3G subscriptions. While this may not necessarily be a bad outcome, it has nevertheless required operators to balance their strategies in launching 3G services. On the one hand, migrating 2G subscribers to 3G networks is likely to result in a corresponding increase in ARPU. On the other, 3G networks suffer from higher depreciation rates and operating costs that may result in lower returns from 3G networks if ARPU does not increase on migration. Operators acknowledge that there is some possibility of that happening once the novelty of things like videophone calls and the ability to watch multimedia programming on 3G phones wears off. Nevertheless, with operators planning to eventually migrate all their subscribers to 3G networks in the future, the main difference in strategy among operators appears to be the speed with which such migration is encouraged. While industry observers have generally encouraged a gradual migration, Singaporean operators appear to have taken a more aggressive approach. As noted above, SingTel, for example, has priced 3G videophone services at the same level as existing voice calls while also pricing 3G data services at a rate 30 per cent lower than that of its slower GPRS service.

### **3.3.3 Mobile content**

To induce mobile phones use, mobile operators have introduced a wide range of mobile specific content from which subscribers can choose. In offering such services, operators have sought to entice users to move from "dumb" data transmissions, such as e-mail and web browsing to more "intelligent" data transmissions that involve higher priced content and services. Some of these are described here:

### Box 3.2: Beauty on call

*Singapore Plastic Surgeon and Dermatologist give skin consultations by MMS*



When mobile phone subscribers in Singapore have an acne breakout or are down with a rash, they will be able to just snap a picture and send it via MMS to the industry experts. Through a recently launched service, renowned plastic surgeons and dermatologists have offered to give tips on-demand to consumers through MMS in Singapore. For a monthly subscription fee of up to \$5, consumers can get skincare tips in the form of text, pictures and video via their mobile phones.

The providers of the service have noted that the impending introduction of the service represents a migration from the paternalistic model of health education where doctors dictate standard remedies to one that is more interactive and immediate. MMS treatments can be customized to skin type, age, and hormonal cycle.

Some 8 more industry players are expected to join in the project.

Source: [www.iskin.tv](http://www.iskin.tv)

### *SMS-based services*

The birth of a mobile-specific content services market in Singapore can largely be traced back to the introduction of SMS-based applications in the late 90s. The downloading of ringtones, logos and icons was immensely popular among the youth in Singapore during that period with multiple mobile content providers entering the market.

At the same time, a number of SMS text based messaging services, such as the delivery of news headlines, stock market report, lottery results and horoscopes were introduced into the market. A Chinese business dictionary service was also available for subscribers using Chinese character enabled handsets. Aimed primarily at the adult and business community, these services did not enjoy the same measure of success as those aimed at the youth, such as SMS chat.

Nevertheless, as a testament to their enduring nature, SMS-content services still remain a popular service offering among subscribers today with all mobile operators continuing to offer these services despite the introduction of richer content that take advantage of higher speeds.

### *Multimedia messaging services (MMS)*

Multimedia messaging services (MMS) based services have proved popular with mobile subscribers thanks in part to a number of applications that have been introduced to stimulate its use. Mobile operators currently provide a host of content available through MMS. These include video clips of sports and news, real estate brochures and “live” traffic shots taken from webcams set up along major thoroughfares.

Leveraging on the suitability of MMS to deliver images to and from consumers easily, a number of non-operator companies have also introduced a variety of services based on MMS (see Box 3.2).

However, the transmission of user-generated content – pictures and videos - has proved to be the most popular service among MMS subscribers. To boost its popularity, mobile operators have introduced tools and applications to further enhance user experiences with MMS services. Applications such as the Singaporean developed “Muvee” software, for example, allows a subscriber to turn raw video footage taken

by a camera phone into a more stylized product. The mobile-based software uses a simple interface that allows the user to edit a video clip by selecting a template that then gets mixed with the video to give it special effects, text and a music soundtrack.<sup>12</sup>

Giving a further boost to user generated content development and distribution, Singaporean-based Wireless Intellect Labs (WIL) – a wholly-owned R&D subsidiary of M1 and a product of the Wired with Wireless WTA initiative - has developed and released a system that enables mobile subscribers with an Internet connection and a "webcam" to access the webcam using an MMS-enabled mobile handset. Dubbed Permodia, the system is designed as an easy-to-use application for end users to set up their own content that could then be made available for public or private viewing. Users simply connect a webcam to the Permodia server and access images through operator MMS services. Unlike traditional webcam systems that transmit a continuous stream of data, the system takes pictures only when requested, thus allowing it to use minimal bandwidth. The system also supports motion detection as well as GPRS and Wi-Fi cameras. The Permodia system is available free on a trial basis from the developer's website. Operator charges are levied for MMS transmissions to the subscriber.<sup>13</sup>

### *Multimedia services*

With the introduction of higher speed technologies, such as GPRS and 3G, together with the launch of new handsets with color screens and the ability to play music and videos, mobile content offerings became more sophisticated. For example, 3G services on offer include music download services that allow customers to browse, preview, purchase and download CD quality full length tracks, java based news services, and "live" streaming video of news channels.

The two 3G operators have also announced plans to launch a suite of 3G content services in the months following their February 2005 commercial launch. These would include sports and local entertainment TV programming designed specifically for the 3G format, news features, 'live' traffic conditions, music videos and 3G games. SingTel 3G also announced that it would also provide a platform for showcasing self-created content such as movie and video clips by budding local talents, and slices of everyday life captured in video form by customers themselves (e.g. citizen reporter and Singapore's funniest videos). While most of the focus of SingTel's launch was on individuals, the operator announced that it was also working on 3G applications for corporations, such as mobile point-of-sales applications and surveillance applications.

Nevertheless, looking at the pricing plans released by some mobile operators during the recent commercial launch of 3G services, it appears that operators view videophone calls as the "killer" 3G application that will drive the adoption of 3G. Although currently too early to tell whether this will be true, it nevertheless appears that operators will have to make significant adjustments to the service in order to increase its appeal. In its current form, video call quality is poor, largely due to the fact that the video is transmitted through a relatively narrow 64 kbit/s channel. Furthermore, most existing 3G phones tend to use a rather low resolution VGA camera for the video calls. As a result, jerky images, which become even poorer in low light conditions, and lack of lip sync are problems that could potentially put off subscribers once the novelty of the service wears off.

## 4 TOWARDS A UBIQUITOUS NETWORK SOCIETY

### 4.1 The Next Generation I-Hub

In February 2005, IDA unveiled its latest initiative and invited industry feedback on its vision of the Next Generation I-Hub, a secured, high-speed and ubiquitous network to drive next generation connectivity. By leveraging on the country's strengths in terms of its pervasive communications infrastructure, pro-business policy environment, and plentiful infocomm skilled manpower, the SupraHub envisages the creation of an island wide ubiquitous network in the period running up to 2009 (see Box 4.1).

To realize this vision, IDA intends to direct its efforts along six strategic thrusts:

*1. Infrastructure deployment for a convergent network*

IDA intends to support the provision of a multi-channel platform that achieves convergence between Wired and Wireless; Data and Voice; and Broadcasting and Telecommunications services. It is considering plans that include developing a favorable IP licensing regime, encouraging IPv6 adoption and investing in fiber to the home (FTTH).

*2. Provision of locations sensing network services*

IDA plans to promote the deployment of location sensing networks by leveraging on wireless technologies such as WLAN, Cellular, GPS, UWB, and RFID. Potential applications for such networks include telematics, mobile games, supply chain visibility in logistics, and patient tracking in healthcare.

*3. Exploring new input/output devices*

IDA proposes to promote the search for new Input/Output technologies that can be applied to seamlessly integrate the physical with the electronic. IDA may consider facilitating R&D into new input/output technologies such as voice activated Telematics.

*4. Exploring new computing devices*

IDA will seek to promote the search for convergent devices that are ecologically integrated for ubiquitous living. IDA may consider supporting potential R&D projects with operators to develop partially or fully integrated portable multimedia devices with new form factors and shapes, and with longer battery lives.

*5. Promoting new media software/content/applications with security features*

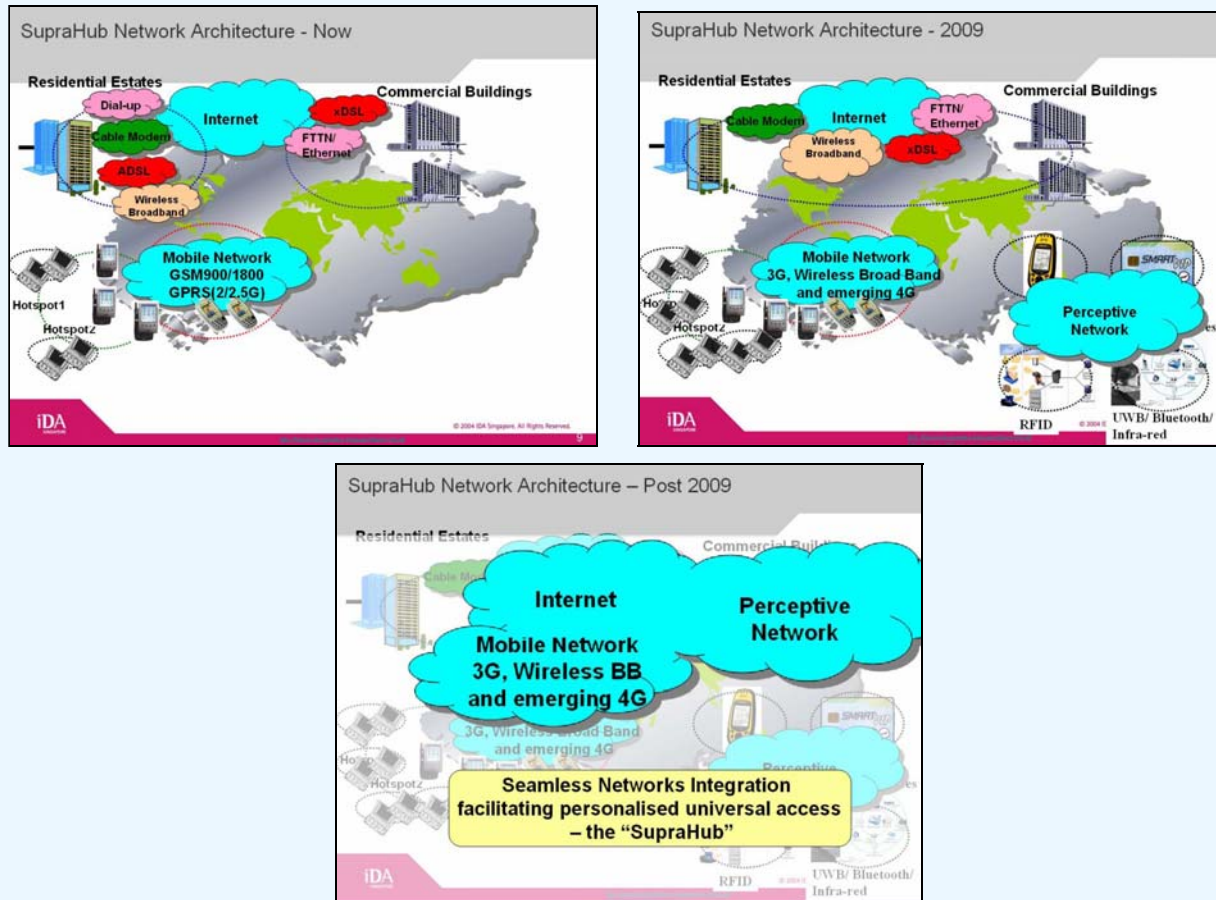
IDA will work closely with other cluster developments in promoting the deployment of suitably secured new media software, content and applications. Potential users include various verticals such as schools, healthcare, logistics, construction, government agencies such as the Police and Civil Defense, insurance and real estate agencies, and the entertainment industry.

*6. Promoting industry alliances/collaboration for ubiquitous computing*

IDA will take an active role in promoting the formation of industry-led alliances, exchanges, and marketplaces while collaborating with industry to deploy infrastructure for ubiquitous offerings. Potential industry alliances can be forged in the areas of inter-roaming, interoperability and inter-working in a multi-operator, multi-platform environment.

The realization of these trusts will support the strategy imperatives of A: Deploying leading-edge ubiquitous network infrastructure for business and individuals for next generation communications and B: Capturing the R&D IP creation and ubiquitous commerce segments of the international value chain in next-generation communications.

**Box 4.1: Building a SupraHub Network Architecture**  
*To 2009 and beyond*



Source: IDA

It is important to note that the SupraHub vision is currently at an early stage of conceptualization. At the time of writing the report, the vision was still in the process of being refined and refocused through public consultations and informal meetings with countries that share similar ambitions. Nevertheless, it has been pointed out that the existing strategies, policies and initiatives, such as the Wired with Wireless programme, continue to lead the country on the path toward a ubiquitous network environment.

## 4.2 Developing the RFID value chain

As a regional logistics hub with a strong manufacturing base, Singapore stands to realize significant benefits by adopting RFID technologies.<sup>14</sup> At the same time, the government and local infocomm companies also see the increasing global interest in RFID technology as a market growth opportunity.

Recognizing the challenges associated with an emerging technology like RFID, such as the lack of international standards, and the limitations Singapore faces, such as the absence of large retailers like Wal-Mart to drive large-scale adoption, IDA decided to adopt a proactive approach to developing the RFID sector. In May 2004, IDA announced that it would invest S\$10 million (US\$5.9m) in a three-year plan to promote the adoption and development of radio frequency identification (RFID) technology along three lines:

- *Alignment of Frequency spectrum and standards for global interoperability;*
- *Building capabilities to develop new intellectual property by building a robust RFID infrastructure in terms of research and development, skilled manpower, and supporting institutions;*



- *Collaboration to catalyze adoption of RFID in key sectors* by using a clustering approach to bring together groups of industry partners, infrastructure service providers and solutions providers to ensure concerted rollout and interoperability.

IDA has taken an aggressive role in accelerating the process of RFID adoption by creating an internal team of RFID evangelists dedicated to the promotion and adoption of RFID technologies. Currently, the team is focused on encouraging and supporting RFID adoption through awareness building and direct assistance in five key sectors: high-tech manufacturing, pharmaceutical manufacturing, consumer packaged goods manufacturing, retail and logistics.

In November 2004, IDA issued a Call-For-Collaboration (CFC) for "RFID for Business Efficiency".

#### **4.2.1 Spectrum policy**

Currently, different countries have allocated different radio spectrum frequency bands for RFID applications (e.g. North America - 902 - 928MHz, Europe/Singapore - 866 - 869MHz, Japan/Korea - 950 - 956MHz). In order to ensure RFID interoperability with Singapore's major export markets - the United States and Europe - IDA realigned its spectrum bands allocated for the deployment of RFID applications. In October 2004, the spectrum for RFID applications in Singapore was set at 866-869 MHz and 923-925 MHz in the UHF bands. The licence-exempt power limit for both bands was also increased from 0.01W to 0.5W, while the power limit for the 923-925 MHz band was increased to 2W for RFID devices only. The 915MHz frequency, which is widely used in the US for RFID applications, is currently used for GSM services in Singapore.

#### **4.2.2 Research and development (R&D)**

As a relatively new technology, R&D on RFID technologies is still on-going in some key areas such global inter-operability of RFID systems, and the reliability of RFID when used in environments with high liquid and metal content. Given the increasing interest in RFID research, IDA hopes to position Singapore as a laboratory for pilot RFID research projects and as a development centre for innovative RFID products and solutions. To date, IDA has implemented plans to assist local and multinational companies in making Singapore a base for RFID research.

A key element of IDA's strategy will be the establishment of joint research facilities with institutions at the forefront of RFID development, such as MIT's Auto-ID Labs, which played a key role in developing the Electronic Product Code (EPC)<sup>15</sup>.

To date, a number of local companies have already taken up the opportunity to do R&D in RFID. For example, Tunity Technologies, a local company specializing in RFID and radio frequency (RF) related systems and solutions, is currently in the process of developing EPC-compliant multifrequency RFID tags that operate in three different RF bands in order to ensure frequency interoperability.<sup>16</sup>

Another local company, GT & T Engineering, is developing an intelligent RFID tag that can communicate with other tags so that information can be relayed accurately to the final data collection point. When used in a warehouse management scenario, a tag on one pallet can communicate with the tag on another pallet in order to obtain a meshed network effect. Pallets that are located further away, which previously could not be located, can now be traced for real time monitoring and retrieval.

In addition to establishing research facilities and promoting local R&D, IDA has also strongly encouraged the setting up of an RFID testing centre in Singapore. NOL, APL Logistics and SUN Microsystems have declared that they will be jointly setting up an RFID Testing and Solutions Centre in Singapore, a first in Southeast Asia. It will provide companies with the necessary compliance testing and checks before RFID tagging of the goods. In particular, the Centre will locate the optimal position to place an RFID tag for the most accurate reading for different products. At the same time, the centre will also free up manufacturers from having to do their own tagging.

In September 2004, a Singapore RFID Alliance was formed with the support of IDA. With the aim of transforming itself eventually into an Asia RFID Alliance, it will develop reference architectures, share best practices and align standards. Its current membership includes Hewlett-Packard, Hitachi, Accenture, Port Singapore Authority (PSA) and EPCglobal Inc. among others.

IDA is also currently in the process of encouraging industry to establish RFID registries in Singapore. It is now trying to attract EPCglobal Inc., the leading organization dedicated to the development of industry-driven standards for the EPC, to set up its Asia Pacific headquarters in the country.<sup>17</sup>

### **4.2.3 Skills and training**

In order to support the growth of an RFID industry in Singapore, IDA has also undertaken the task of increasing the supply of relevant skill sets. IDA is currently working with a number of relevant organizations and training bodies to accomplish this aim. It is currently working with Institutes of Higher Learning and training providers to develop new courses RFID skills training. The two major state-run universities—National University of Singapore and Nanyang Technological University—are developing courses to provide electrical engineering graduates with specialized RFID knowledge while a local college, Republic Polytechnic, is developing new RFID curricula for students and executive RFID courses for businesses. The college is also conducting a survey to determine industry readiness for EPC, their concerns and gaps. The survey was designed to be used as a tool for the development of government programmes to cater to the industry needs

In addition to educational institutions, the local logistics industry has also introduced executive training in RFID technology. In November 2004, two RFID courses were launched: the first by The Logistics Institute - Asia Pacific in collaboration with Cambridge AutoID Labs; and the second by the Singapore Manufacturers' Federation in collaboration with RFID Focus.<sup>18</sup>

## **4.3 Applications and services for a ubiquitous network environment**

### **4.3.1 Broadband-based applications**

#### *Connected homes*

With broadband network coverage extending to 99 per cent of all homes and with close to half the households in Singapore subscribing to broadband, a significant market opportunity exists for the development and deployment of innovative home networking applications and equipment. Currently in its infancy in Singapore and around the world, interest in home networking is expected to grow sharply within the next few years. IDC, for example, expects the worldwide installed base of households with a network to grow from 37 million in 2003 to nearly 111 million in 2008.

Inspired by the strong growth potential exhibited in the home networking market, IDA launched its Connected Homes Programme in April 2002 to create a nation-wide test bed environment for the industry to develop, pilot and deploy innovative and integrated end-to-end solutions for homes.<sup>19</sup> Leveraging on the existing Singapore ONE infrastructure and services, the programme also aims to extend the benefits of a Connected Lifestyle to Singaporean homes and communities. There are two main thrusts to the Connected Homes Programme - "Connecting the Home" and "Connecting the Community". The first thrust aims to encourage the development of a suite of solutions connecting a variety of home appliances and communication devices, while "Connecting the Community" is targeted at linking different aspects of the community such as health providers, educational institutions, community groups and businesses.

Following the launch of the programme, IDA issued a Call for Collaboration (CFC) for the first phase – Connecting the Home - to address the lack of an integrated home networking solution in the present market. Under the CFC, IDA provided financial support to five consortia comprising content and application providers, network equipment manufacturers, systems integrators, technology providers and broadband service providers in their development and trial of their solutions. 35 new solutions were developed through the CFC with over 400 households involved in their trial. A number of solutions have been commercialized through deployment in new condominium developments. The solutions developed include integrated data communications and home entertainment, as well as home automation, control and security (see Box x).

Some of these solutions have been commercialized, for example, UniHome's Connected Home solution has been deployed on a modular basis in more than six condominium developments in Singapore. The total project value of these rollouts by UniHome is estimated to be over S\$1.2 million (see Box 4.2).

With the conclusion of the Connecting the Home trials in March 2004, a CFC for the second phase of the Connected Homes project –Connecting the Community – was issued in January 2004 to seek out proposals for integrated IT solutions which can address common community needs. Four consortia were selected in August 2004 and a public trial to test the proposed solutions was scheduled to start in February 2005 involving over 2,500 trial users.

The consortia are made up of 23 companies, ranging from IT solution providers to Citizens Consultative Committees (CCCs), umbrella bodies for grassroots organizations. A total of 24 solutions were presented for trial. These included solutions to address a range of needs, starting from the family to the general community. For example, Golden Years Community consortium offers a suite of services targeted at the middle-aged and senior citizens (aged 50 years and above), offering personalized products and services like healthcare, shopping and travel, to encourage them to lead more active and engaging lifestyles. A key service includes the BioAlert, a device which when strapped onto the body, can detect abnormalities in heartbeat and automatically sends out alerts wirelessly. The readings are transmitted via Bluetooth from the chest strap to a cellphone nearby, which then sends the information to a managed call center. Family members will in turn be alerted once an aged parent or grandparent has his or her blood pressure hitting critical levels.

For the wider community, a solution that enables parents to easily monitor their children's progress in school through SMS and email was also introduced. Other proposed applications benefiting the general community included real-time information alerts via electronic notice boards at common community areas and common terminals for residents to request for services and provide feedback to management councils and property managers, as well as book common facilities and pay for common services.

#### *Connected schools*

The use of technology in educational establishments in Singapore has been a long-standing focus of government efforts to build an infocomm savvy society. Schools were one of the first public institutions to be connected to the nationwide broadband infrastructure. In the field of education, technology is seen as playing a dual role, serving as both a pedagogical tool as well as a means of sensitizing students to infocomm technology.

Leveraging on broadband connectivity to schools and the increased availability of wireless solutions, IDA has launched an initiative in partnership with Microsoft Singapore to drive the testing, development, research and showcasing of innovative infocomm technologies in education. In October 2003, the Backpack.NET initiative was launched. A five-year undertaking, it comprises a number of projects aimed at enhancing the learning experience through the use of tablet PCs, 'digital ink' and other emerging infocomm technologies. It also aims at creating a framework for researchers, industry players and schools to develop software and digital content solutions.

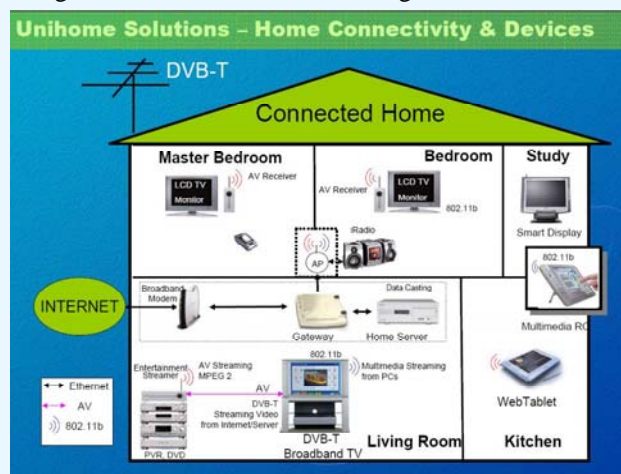
Under the first phase of the initiative, cohorts of students in selected schools were equipped with individual tablet PCs that were enabled with wireless connectivity and that contained digitized textbooks. They allow students to communicate with teachers while giving them access to lesson materials and Internet resources anywhere on school grounds. In this way, students are given greater one-to-one teacher access while also allowing teachers to use the application to monitor students work and progress at any time, aiding and encouraging them in their studies by instantly providing feedback. As an example of their use, students are taught to note and share their qualitative observations with other students while conducting a variety of scientific experiments, while during Digital Art sessions, students are taught to draw illustrations and images directly onto the tablet PC screen and then manipulate the images using computer graphic software. Wireless applications also allow students to participate in lessons outside the class while conducting real-time consultations with experts in the subjects.

#### Box 4.2: Connecting the Tan family home

##### *UniHome's solutions for the Connected Home*

During the six-month "Connecting the Home trial", IT professional Lawrence Tan and his wife, Janet, have started their workday mornings with a quick glimpse at iPronto. The wireless web pad - a prototype developed by Philips Electronics - updates the busy 40-somethings on key information that is refreshed every morning before they head for work. Apart from iPronto, the Tans' home was also fitted with a wireless device detachable PC monitor, a home surveillance webcam with motion detection and a DVD/ Hard Disk Drive recorder that can automatically tape TV programmes on a computer hard disk. These devices were connected to an integrated gateway accessed through a home portal that enabled the Tans to remotely access and control them. The complete UniHome solution brings together the following elements:

- *The Home Gateway/Server* - Connects the data, entertainment, home automation and security networks and devices to each other, and to the Internet.
- *The Home Portal* - Provides platform for services and content aggregation. Users enjoy convenient and secure single access point to connected home-related services and also to access and control home devices. The portal provides many aggregation tools, e.g. webservices, single-sign-on, payment gateway, messaging gateways, etc. to link up third party service providers. Trial users enjoy video-on-demand, e-learning, SOHO tools, and community services from many service providers via the home portal.
- *A PC Camera Surveillance & Security Service* - Users can monitor their homes from anywhere via broadband or dial-up Internet access. Motion or noise detection can trigger recording and intrusion notification via SMS. Additional on-demand viewing via hand phone will be deployed shortly.
- *The Philips Streamium MC-i200* - The world's first broadband Internet micro hi-fi system offers instant access to multiple online music services. It also plays music files store on home PCs.
- *iPronto* - The iPronto enables users to manage digital home devices through an integrated, always on, and simple interface. From any part of the house, users can access entertainment devices or go to a website to instantly to access information.
- *Digital Multi-Media Receiver* - A WiFi enabled audio-video streaming device which allows JPEG/MP3/MPEG-1 contents from the home computer streamed anywhere in the house.
- *TVtoTV link* - Contents from DVD or VCR media can be streamed wirelessly to any other room.
- *DVD/HDD device* - Provides flexibility of freezing terrestrial broadcast at any time through time-shifting TV viewing.
- *DesXcape, Detachable Monitor* - Enables PC to be used anywhere in the home through wireless network.
- *VideoCast* - VideoCast is a new digital service that deploys IP technology to stream content as well as to transfer files onto the PC over a terrestrial platform. For the trial, video streaming of movie trailers, local dramas and sitcoms as well as electronic newspapers, catalogues, and magazines were available for downloaded to the trial user's PC.
- *Digital TV Services* - Digitized versions of current analogue TV channels.



Source: Computer Times and Universal Gateway International (figure)

Preliminary findings taken from the first broad trial have indicated that the use of mobile learning technologies facilitated independent learning while multi media content made schoolwork more interesting. Teachers also found the transition to using tablet PCs for teaching to be relatively smooth.

As part of the initiative, Microsoft Learning Gateways have also been deployed in two schools. The Learning Gateway is an Internet environment that allows students to do and submit their homework online, to participate in group discussions, and to collaboratively work on group projects from different locations all over the country. Teachers are also able to deliver lessons and assessments over the Internet. Applications on the portal help teachers to mark assignments and assessments, allowing them to devote more time to teaching. Parents are also able to track their children's academic progress on the portal on a daily basis.

In March 2005, a BackPack.NET centre was opened at the National Institute of Education (NIE), the national teachers training institute, to showcase and develop the use of innovative technology in education. Technologies on show include a Bio Genetic Laboratory scenario which showcases learning-based technology based on RFID for easy retrieval of up-to-date data; System Modeling Tools to engage pupils in investigative learning; Digital Geography text books where entire book contents are digitized and modified to feature multi-media and collaboration applications, and resource links on the Internet; and applications enabling real-time connections to experts from around the world. The Centre is currently researching and testing new applications for immediate application such as a Composition Automated Testing System whereby teachers can evaluate the students' written proficiency in Chinese language.

### *Connected Hospitals*

Seeking to extend the benefits of network technology to all public sectors, the Singapore government has also embarked on a healthcare initiative aimed at testing and developing the use of infocomm technologies to bring about a patient-centric, seamless, safe and cost effective healthcare system.

Under the Healthcare.NET initiative launched in November 2004, Alexandra Hospital (400-bed general and acute care hospital), IDA and Microsoft Singapore embarked on a series of projects aimed at integrating and upgrading existing legacy systems with innovative technologies such as biometrics, smart cards and RFID.<sup>20</sup>

#### **Box 4.3: Mobile data in distribution services**

*Wireless sales force automation leads to revenue growth and cost savings*

Vincent Lim used to have hundreds of numbers stored in his head. As a sales representative of a consumer goods distributor, PSC Corporation, his job was to visit retail outlets and supermarkets to take orders from them. He had to memorize the prices of many individual items as customers often needed to know the prices on the spot. With his company handling over 8,000 different product lines, flipping through his paper files at the customer site would simply be too laborious.

In June 2004, his company transformed the pen and paper sales & ordering manual process into a high-tech sales force automation system. Today, Mr Lim uses an HP iPaq 2210 PDA he needs. At the various retail outlets, he simply inputs the customers' orders into the PDA. The price for each product is listed and the PDA also shows the current inventory level of each item at PSC's warehouse, so he can immediately inform his customer on stock availability and set a date for the goods to be delivered. Previously, he would have had to call or check with the warehouse department on the stock availability and inform the customer later.

He can also inform the customers of the current level of their credit facility, and collect payment on behalf of his company without the need to verify figures with his accounts department. The new order information is transmitted back to the back-end servers at the office in real-time over GPRS to the office.

According to the company, the introduction of a sales force automation system has been a great boon. With the new system, sales representatives have been able to visit 38% more customer outlets. In addition, turnaround time to fulfill the orders has dropped by half. This increase in productivity has led to an increase in revenue by up to about 26% for the first five months after implementing the system (June to Oct 2004) compared to the preceding five months (January to May 2004). Operational costs have also dropped considerably, largely due to substantially lower invoicing errors. The errors have plunged from a 3% average to 0.08%.

Developed by Singaporean software developer Maya Systems Consultants, the new sales force automation system is also providing PSC's management with better understanding of customer's buying patterns as the system generates business analytics and reports.

*Source:* Adapted from IDA case study

In February 2005, the first phase of the three-year initiative was introduced. Dubbed the Clinical Digital Dashboard, the wireless solution is currently being piloted at the Alexandra Hospital's Department of Emergency Medicine (DEM). Using wireless infrastructure and Tablet PCs staff are now able to register, consult, treat and prescribe medication to patients all at one go.

Alexandra hospital also served as the test-bed for RFID applications in Singapore's efforts to contain the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003. This initiative is described in greater detail below.

### **4.3.2 Mobile-based applications**

#### *The mobile enterprise*

As a general trend, increases in mobile data transmission speeds have been matched by increased usage of data transmission applications such as e-mail and web browsing. A host of mobile business solutions such as inventory control, fleet management and similar services that rely on remote database access have also been developed to take advantage of mobile data and Internet access (see Box 4.3).

#### *Location based services*

The development of LBS services offered by mobile operators in Singapore have benefited largely from the initiatives undertaken by the Singapore government through the Singapore Land Authority (SLA) and IDA. In May 2002, the SLA issued a call for business collaboration (CFBC) to support the wireless industry in overcoming the high cost of producing quality map information. As a result of the CFBC, the SLA issued LBS Map Content Provision licences to three industry consortia, allowing them to use its comprehensive map content to develop a location-based platform. In February 2003, IDA launched another LBS CFC together with SLA, the Land Transport Authority (LTA), Singapore Tourism Board (STB) and the National Heritage Board (NHB). This initiative was aimed at supporting developers and providers of LBS applications to offer more sophisticated Information and Navigation Services, Resource Management Services, Safety and Emergency Services, Community-based applications and interactive wireless entertainment.

In September 2002, under the Wired with Wireless Wireless Technology Alliance initiative, the Siemens Location Enabling Centre was set up as a test and training centre for the development of LBS applications. The centre offers a comprehensive LIF standard--based Location Based Service (LBS) test environment which brings together the Siemens Location Platform, Siemens Location Enabling Server and GeoToolBox Server and the multi-layered digital Singapore maps from the Singapore Land Authority (SLA).

First introduced by SingTel in March 2001, two out of the three mobile providers in Singapore currently provide location-based services (LBS) to their subscribers. LBS services on offer allow users to receive vicinity-specific information such as the location of nearby supermarkets, cinemas post offices and ATMs. Users can further define their search by sub-categories like cuisine types for restaurants and healthcare services by specialization (see Box 4.4). LBS services can also be used to help customers book a taxi and find out which bus services are available nearby. Using an LBS platform developed by Wheresoft, an SLA LBS Map Content Provision licensee, StarHub also offers a "need of the moment" service that provides a proximity search for urgent needs such as the nearest polyclinics, dentists, police and petrol stations, 24-hour shops, etc. The smart proximity search function automatically extends to cover more areas if none is found within the immediate vicinity.

#### *Mobile payments*

In May 2001, IDA invited proposals for a Mobile Payments Call for Collaboration under the Wired for Wireless programme. The first in a series of CFCs conducted by IDA, the M-Payments CFC sought to develop a mobile payments infrastructure in Singapore through cross-sector industry collaboration. Five months later, IDA announced the award of the CFC to four consortia to trial five different mobile payment solutions. It supported the venture with grants totaling SGD20 million. Within one and a half years, the consortia successfully deployed the underlying m-payments infrastructure as well as a breadth of mobile payments applications and services. These included the payment of purchase of movie tickets at selected cinemas, the purchase of travel insurance, person-to-person money transfers, and bill and fine payments. The CFC also resulted in Asia Pacific's first Wireless Public Key Infrastructure m-payments trial.

**Box 4.4: A tour guide in your pocket**

*LBS services for the tourist industry in Singapore*

Since December 2003, a prepaid location based and real-time information service has been available to travelers visiting Singapore. Offered by SingTel and Landmat, an international mobile content provider, the CitySIM service offers visitors to Singapore tourist information linked automatically to their location, via their mobile phone and prepaid SIM card, which they can purchase on arrival. Information available includes locations of restaurants, banks, nightlife attractions - a personalized "tour guide" on a phone. The service also features a chat service that allows visitors to find, chat and share their experiences with other CitySim users in Singapore.



Users of the service requesting location-based information are guided by menus, which then retrieve the requested information via a SIM-based browser from a central server. CitySim cards are available for purchase at the price of SGD20.

Source: CitySIM at <http://www.citysim-singapore.com/how.htm>

Results since then, however, have been disappointing. Two years later after the four consortia launched their m-payment services to the public in March 2003, only two remain, with one subsumed under a larger online payment system. By mid-2004, only 70'000 subscribers had registered for the various m-payment systems despite much higher initial projections.

Industry observers have put forward a number of possible reasons that explain the low adoption rate. Firstly, as originally designed by the consortia, the use of mobile payment services involved a complicated procedure. Subscribers were required to open an account with a participating bank or service before mobile payment services are made possible. A personal ID, an SMS or a certain code was then required to make the actual mobile payment. Secondly, as each consortium operated a different mobile payment system, a subscriber seeking to use the services of a company in a different consortium would require a separate registration and payment procedure. More significantly, mobile payments suffered and continue to suffer from aggressive competition from a wide range of convenient payment methods already available that include online and in person payments through credit cards, debit cards, CashCards and cash.

Although one consortium has started to simplify mobile payments by developing a Java-based application that presents subscribers with a simpler interface, the hurdles of interoperability with other mobile payment systems and competition with other payment methods still remain.

#### *Machine to machine communications (M2M)<sup>21</sup>*

Leveraging on wireless technologies and the mobile communications network in Singapore, a number of M2M communications solutions have been introduced for a growing number of applications. These include, for example, remote monitoring, data collection, stock maintenance and configuration of vending machine operations and the remote monitoring of buildings and structures under construction (see Box 4.5). The Land Transport Authority (LTA) is also currently exploring the use of M2M solutions to maintain street lighting operations in Singapore. The system will replace the current labor intensive system of visual inspections of street lighting by providing "live" monitoring alerts of the street lighting systems via PDAs and SMS.

Currently, much of the application development activity in M2M in Singapore is centered on RFID and low rate wireless sensor networks which involve product tracking, distribution, monitoring and data collection.

#### *Mobile computing*

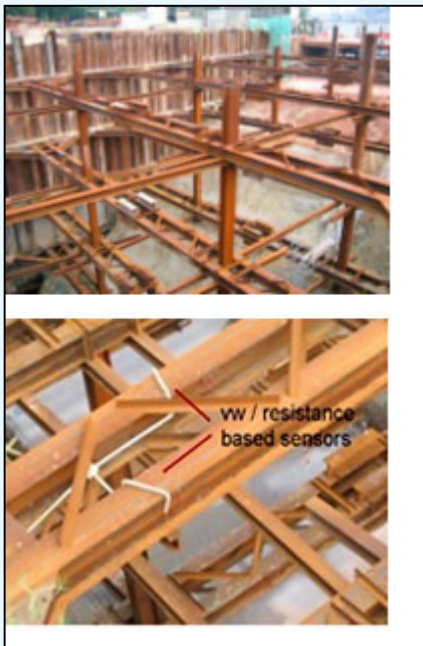
Currently, mobile handsets and PDAs suffer severe limitations in terms of processing power, limiting the range of software applications that can be run on them. These devices tend to run stripped-down or "lite" versions of full-fledged desktop software applications.

With the aim of realizing a vision of true ubiquitous computing, a Singaporean company undertook the development of an operating system for mobile devices that relies on the increasing amounts of bandwidth available on mobile networks. The MXI operating system developed by Radix is split into two components - the server side and the device side. 80 per cent of the processing takes place at the server side, which

includes running the applications and only 20 per cent takes place at the device level. This way, the hard-core processing can take place at the server level, while the smaller data chunks are transmitted to the wireless device over wireless systems like GPRS, 3G and WiFi. By using the MXI platform, any desktop application developed for the Windows, Java, Linux and Palm environment can work on the mobile device. Users can potentially get full versions of programmes like Microsoft Office and Sun's StarOffice to run on their MXI-enabled mobile devices. In addition, all data is stored on the server side, allowing more games, videos and digital music to be stored by the consumer. Radix is currently working to licence its patented MXI platform to mobile services providers.<sup>22</sup>

**Box 4.5: Preventing construction site failures through M2M**

*M2M monitoring systems at constructions sites*

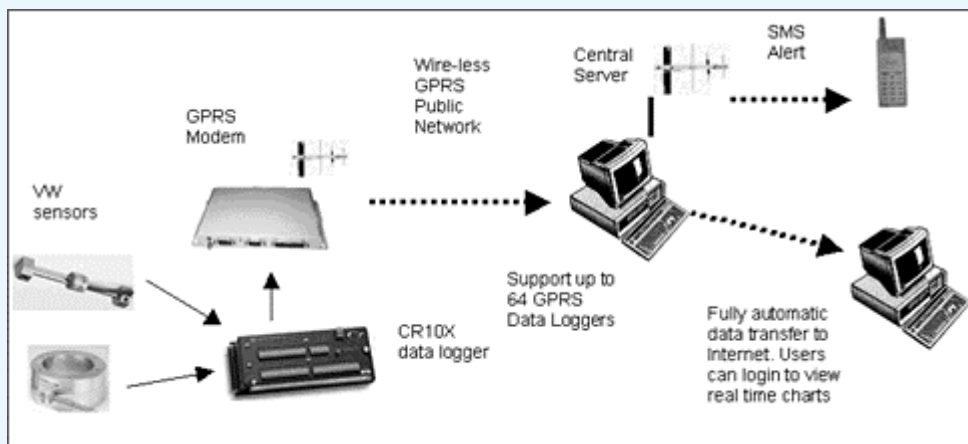


In the construction industry, there is a recognized need for a continuous monitoring system that provides real-time access to site data and alerts in the event of any signs of structural movement. Currently, construction firms use automatic data loggers to provide reliable and consistent sensor data from project sites. Remote sites use a GSM wireless monitoring system to collect and upload data to a central computer at fixed intervals. The system then sends the data to users in cycles. Although data is captured over extended periods, the cost of conducting continuous GSM online monitoring of sensor readings is prohibitive.

In response to this problem, SysEng, a Singapore based company, developed an eMonitoring System, (eMs), a GPRS enabled M2M solution that provides the construction industry with a cost-effective continuous monitoring system. Currently, eMs is used in a number of deep excavation projects in Singapore to monitor strut forces in a temporary retaining system for a cut-and-cover tunnel, such as the on-going Kim Chuan Mass Rapid Transit (MRT) Depot project (see left picture).

Using the system, the eMs is connected to arrays of vibrating-wire (VW) or resistance based sensors. It records the data at time intervals. Data acquired is stored and processed in a data logger and sent immediately to a central server via GPRS. An automatic computer system at the central server then uploads the monitored data to dedicated web pages.

Monitored values are simultaneously compared with pre-set review levels and SMS alert messages will be sent to users when the values exceed the trigger threshold within 60 seconds. As GPRS costs depend on the amount of data transferred and not on connection time, the automatic data logger is able to connect continuously to the central server without incurring high costs. Data transmitted between logger and server is transmitted in real-time, eliminating connection time delays.



Source: eMs at <http://www.emonitoring-system.com/>



### 4.3.3 RFID-based applications

#### Road traffic management

Singapore's Electronic Road Pricing System (ERP) is the first in the world to use RFID technology to effectively track and manage road traffic volume at different times of the day. This traffic management tool is effectively an electronic toll system that deducts a prescribed road use fee from a stored value smart card inserted in a RFID based in-vehicle unit (see Box 4.6).

In addition to the ERP system, the LTA also relies on other wireless solutions to manage traffic flows in Singapore. For example, GPS based devices located in taxicabs relay information on traffic speeds back to the central traffic control management system for traffic planning purposes.

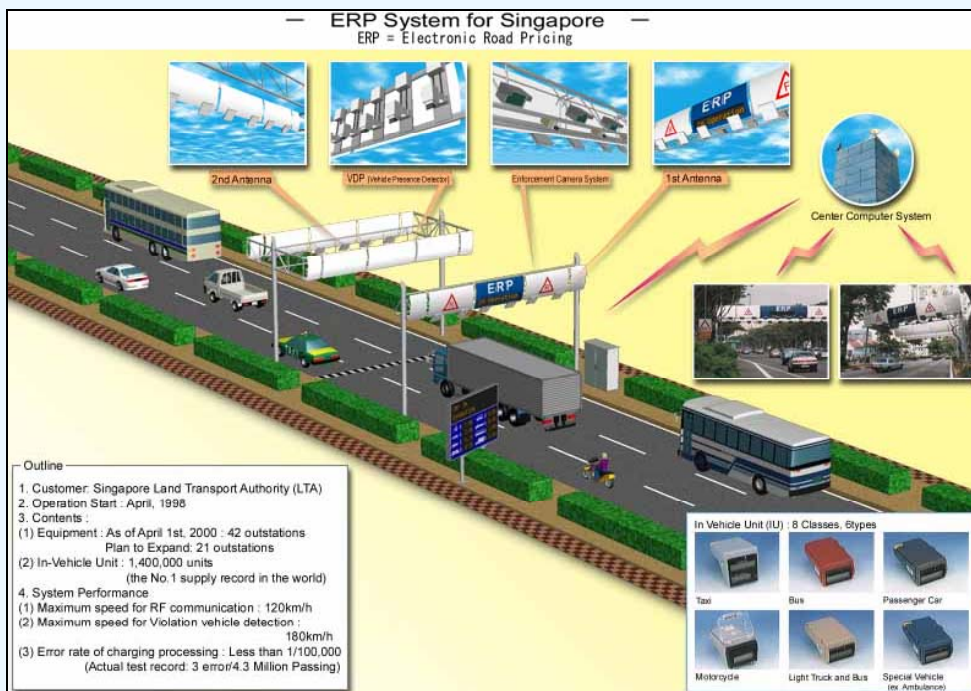
#### Box 4.6: Pay as you use

##### Singapore's Electronic Road Pricing System

In 1975, Singapore implemented the world's first road pricing scheme to reduce traffic congestion. The scheme was called the Area Licensing Scheme (ALS) and motorists then had to purchase daily or monthly licences to enter the Central Business District or Restricted Zone (RZ) during restricted hours. The scheme was manually run, involving the visual inspection of physical licences displayed on vehicle windscreens by inspectors positioned at entry points into the RZ. It was widely seen as a costly, labor intensive and inflexible process.

In another world's first, an automated electronic road pricing (ERP) system was introduced in 1998 to manage traffic entering the RZ. Under the system, the RZ is surrounded by an electronic boundary demarcated by ERP overhead gantries. All vehicles -- except emergency vehicles -- have to pay a fee to enter this area from 7:30am to 7pm on weekdays. ERP fees vary depending on the time of day and the kind of vehicle driven. In September 1999, the ERP system was extended to some key arterial roads beyond the RZ. The ERP system is based on a pay-as-you-use principle. It uses a dedicated short-range radio communication system to deduct ERP charges from CashCards. These are inserted in the RFID in-vehicle units (IUs) of vehicles before each journey. Each time a unit passes through an ERP gantry when the system is in operation, charges are deducted automatically. All vehicles in Singapore, including motorcycles, have this device installed.

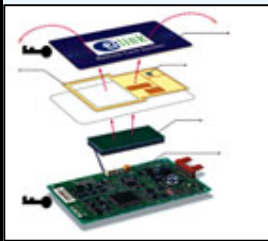
For purposes of traffic management, the LTA periodically reviews the traffic conditions on the expressways and roads where the ERP system is in operation. After each review, ERP rates are adjusted where necessary to minimize congestion on the roads. The ERP system has been effective in maintaining a speed range of 45 to 65 km/h for expressways and 20 to 30 km/h for major roads.



The LTA is currently in the process of planning for the next stage of development of the ERP. Solutions involving the use of GPS and the use of EZ-link contactless RFID cards in place of CashCards are currently under study.

Source: LTA

#### Box 4.7: Contactless cards



##### *Technology behind the ez-link card*

The ez-link card is a compact card conforming to ISO/IEC 7816 card dimensions, which is similar to a credit card. The card surface is made of PET and a tamper-proof IC chip and antenna are built into the card. Both the card and the reader communicate using radio wave via wireless communication. The sensing distance between the card and the reader is up to 10cm. The card itself contains no battery but operates from electromagnetic energy received from the reader. Encryption techniques prevent eavesdropping and fraudulent use. Being contactless, transaction time involving the use of the card is kept to a minimum (approximately 0.2 sec).

Source : <http://www.ezlink.com.sg>

#### *Parking*

The use of automated RFID-based parking systems is widespread in Singapore. Leveraging on the ubiquity of in-vehicle RFID units in vehicles in Singapore, a large number of car parks in Singapore, both public and private, are equipped with automatic gates outfitted with RFID readers that can detect the IUs and deduct parking fees from the inserted CashCards. With the RFID-automated system, throughput is increased, attendants are no longer required, and billing and data accuracy has improved.

In addition to controlling access, the RFID systems can also collect parking use data such as how long cars stay parked and how many cars use the car park each month, allowing the parking operators to better evaluate and manage parking capacity.

#### *Public transport*

In 2001, the Enhanced Integrated Fare System, better known as the EZ-link card system, replaced the magnetic stored valued farecard system used for public transport in Singapore. A contactless smart card, the EZ-link card was introduced to relieve commuters of the need to remember distance related transport fares payable and to reduce bus boarding times at bus stops (see Box 4.7).

There are currently over 6 million EZ-link cards in circulation with over 4 million financial transactions taking place daily through the system.

#### *Health*

During the Severe Acute Respiratory Syndrome (SARS) outbreak in 2003, Singapore hospitals used a specially developed RFID-based Hospital Movement and Tracking System (HMTS) to trace the movements of health care workers, patients and hospital visitors who may have come into contact with infected individuals in hospitals. All visitors and staff who entered specified hospitals were obliged to provide identification and contact details and were then issued a card with an embedded RFID transponder. The active devices continually transmitted RFID signals to readers placed around the facilities, allowing authorities to track and identify the correct visitors and staff for quarantine in the event any patient they came into contact with was infected by SARS.

The incubation period of the SARS virus is 10 days. The system was set up to store information on visitors for 21 days to ensure that information about all the contacts with a probable SARS patient remained available well after the incubation period ends. Hospital staff were able to access the application through a Web-based portal on the hospital's Intranet. If a patient was suspected of having SARS, staff would run an immediate check to find out who came into contact with the patient, in which zones and at what time. The confidential information is deleted from the system after 21 days.

Singapore's Defense Science and Technology Agency (DSTA) developed the system after it received a request from the Ministry of Health to explore ways of tracing contacts within a hospital should there be a suspected SARS case. DSTA evaluated several options, but quickly settled on RFID because of its ability to track people without interrupting operations in the hospital or requiring staff to do much additional work. The system runs off of the hospital's existing local area network and was built with off-the-shelf RFID tags and readers. It was tested before implementation and did not interfere with hospital equipment.

#### **Box 4.8: Speeding Up Library Services**

*The Electronic Library Materials Management System (ELiMS)*



Established in 1995, the National Library Board (NLB) is the largest library-managing agency in Singapore with more than 10 million library materials. It oversees the management of the National Library, two regional libraries, 20 community libraries, 28 community children's libraries, as well as libraries belonging to government agencies, schools and private institutions. It manages a library system with one of the highest loan rates in the world with an average of 25 million loans per year.



Under the NLB's traditional manual book loan system, a large number of library staff was needed at the frontline, to stamp books for loans and returns. This resulted in an acute shortage of library staff available to provide value-added services, such as locating library materials for library users, as well as in long queues to borrow and return books. As a result, at the end of the 90s the NLB sought a solution to meet the increasing volume of library loan transactions without increasing its library staff strength.

In 1998 the NLB implemented an RFID system, known as the Electronic Library Management System (ELiMS) to facilitate automatic, multiple object identification, tracking and sorting and data collection. This deployment of RFID technology for public use in a library environment was a world's first. It employed a proprietary system supplied by GemPlus that used embedded RFID chips in books to store information such as a book's title and call number. In 2001, the NLB started to acquire RFID tags based on the ISO 15693 open standard such as the Philips I-code chips. Since 2002, the NLB counted eight million I-code chips out of its 10 million tagged library items. The rest of the RFID chips are still from Gemplus, which the NLB will phase out when library items reach the end of their six-year shelf life.

With the implementation of ELiMS, the NLB reported that library checkout times for borrowed materials were reduced by more than 30 minutes to an average of less than 5 minutes with no waiting required for book returns. Stocktaking was also made easier as a trolley fitted with an RFID tag reader is simply pushed pass the shelves in the library to pick up item information. As a result library staff were freed to focus on providing value-added services such as membership and enquiry services. Significantly, the NLB reported that it saved SGD 50 million a year since implementation, mainly in manpower costs, because of its automated borrowing process of scan-and-go at borrowing stations.

Source: See NLB at <http://www.nlb.gov.sg>

#### *Libraries*

The National Library Board (NLB) of Singapore is the largest RFID technology user in Singapore with over ten million library items tagged. It was also among one of the earliest adopters of RFID technology in the country having started in 1998 when it put RFID tags on books under the Electronic Library Materials Management System (ELiMS) that automated a large number of library services (see Box 4.8).

In 2004, the NLB issued a tender to upgrade its library-wide RFID system (excluding RFID tags) in order to provide new services to its members. Some of the new RFID-based services envisioned include a book recommendation service based on a member's borrowing patterns captured by RFID readers and a book pinpointing service that allows members to locate the exact physical location of a book by simply referring to the catalogue on the NLB website or at enquiry kiosks at libraries. With the new RFID system, the NLB also expects to shave two seconds off the present borrowing time and to allow members to return multiple books at one go at book drops.

#### *Homeland Security*

Recently, Singapore became the first port in Asia to be selected for the pilot project under the U.S. Container Security Initiative. The initiative aims to prevent the smuggling of weapons of mass destruction into the United States through its seaports by requiring the placement of RFID seals on all containers bound for U.S. seaports. The technology that will be used is based on The U.S. Department of Defense's Total Asset Visibility (TAV) network, a system that was built to improve the tracking and security of shipments from the

U.S. to forces overseas. It features RFID tracking of cargo containers, electronic event-driven alerts, anti-tamper systems, virtual inspections and authenticated audit trails. The TAV network is built on existing U.S. and international standards and on the Universal Data Appliance Protocol (UDAP), which allows open "plug and play" integration of automatic data collection devices, such as RFID and GPS, along with sensors, scanning, and biometric systems.

The first phase of the initiative's deployment calls for a single system that can secure containers using e-seals, register individual port employees, and authorize roles. The system will capture relevant information and is designed to complement other security initiatives sponsored by the U.S. government.

#### *Logistics and manufacturing*

In the area of logistics and manufacturing, a number of Singapore-based companies have adopted RFID technology to meet their specific needs. In the manufacturing sector, for example, Hewlett Packard is currently conducting a trial together with a local supplier and a logistics service provider to achieve full traceability of their server and storage product line.

In the aviation sector, the Airbus Centre located in Singapore was the first outside of Europe to implement an RFID system to keep track of the tools loaned out to aircraft maintenance centers. It is a mandatory requirement by airworthiness authorities for all airlines to track essential data related to aircraft tools, such as historical usage and maintenance, in order to ensure safety. With the use of RFID, Airbus has been able to increase the availability of tools due to a quicker turnaround time made possible by more efficient receiving and issuing processes. The RFID-based system also enabled Airbus to achieve higher data accuracy with automatic data capturing.

In the area of logistics and distribution, RFID systems have been implemented for similar reasons of efficiency. Logistics companies such as Grocery Logistics of Singapore (GLS) and YCH, a local supply chain management company, have sought to improve the tracking of goods and materials through RFID use.

In the agri-veterinary sector, smart tags are becoming more popular for use as ear tags for stock or underskin tags for horses or pets to allow the animals to be traced. In Singapore, the Singapore Article Number Council (SANC) together with the Agri-Food and Veterinary Authority (AVA) use RFID chips to tag endangered wild Arowana fish.<sup>23</sup> This facilitates the export of the cultivated second generation of the Arowana fish from the breeding farms.

#### *Retail*

With more than 6 million contactless cards in circulation, the ez-link public transport payment system represents the most widespread RFID-based payment and individual identification system. Beyond public transport payments, the card is also used for a variety of purposes including retail payments, access control management (security), stock management and loyalty and membership programmes. McDonald's Restaurants, for example, allows payment by ez-link cards through card readers setup at its counters. Nevertheless, despite the ubiquity of ez-link cards only a small number of establishments have adopted the system largely due to higher setup costs as compared to established alternatives such as credit cards and ATM cards.

On a smaller scale, motorists in Singapore have been able to purchase petroleum using an RFID-based automated payment system using vehicle-mounted or key mounted transponder tags at all ExxonMobil filling stations since 2001. An RFID reader integrated in the pump reads the unique identification code on the transponder tag that is linked to the customer's payment account for billing purposes.<sup>24</sup>

#### *Conventions and events*

As a popular convention venue, Singapore has occasionally used RFID technology to trace delegates at large conferences and conventions in the city. For example, during the Global Entrepolis@Singapore 2003 convention, an enterprise, innovation and technology convention, RFID systems designed by TunityTech were used to track and locate over 10'000 conference delegates. With the RFID tracking system used, it was possible to locate each delegate's real time physical position within the conference venue at Suntec City. Each delegate was given a credit card sized RFID-enabled tag that interfaced with 60 readers placed all around the building to mark their physical location at all times. The RFID locator service was part of a business matching service suite of applications that included a delegate smart search system, an electronic

delegate contact list manager, a delegate-to-delegate personal messaging service, and delegate-to-delegate SMS services.

## 4.4 Policy challenges

### 4.4.1 Spectrum management

Operating in the context of a small island with a dense population, IDA recognizes the importance of ensuring that spectrum resources are used efficiently to meet the present and future needs of the country. At the same time, IDA also pursues the development of the local infocomm industry in Singapore through its spectrum management policies.

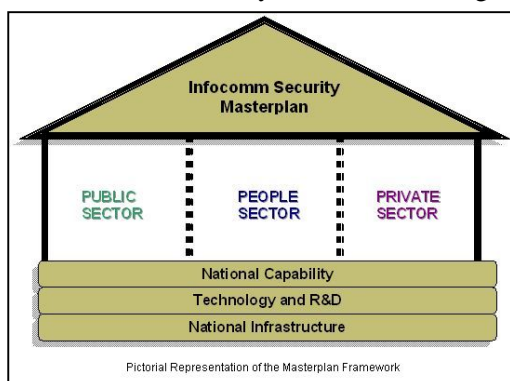
Since its unexpected auction of 3G spectrum – industry observers predicted IDA would adopt a beauty contest mechanism - IDA has clearly stated its adoption of the auction methodology as the mechanism to allocate spectrum. In its stated view, it considers that a market-based allocation approach is more effective in ensuring spectrum optimization by operators. It also is considered an efficient, objective and transparent mechanism. Prior to this change, spectrum was traditionally allocated on an administrative basis and charged on a cost-plus recovery pricing approach.

In addition to the adoption of a market-based allocation mechanism, IDA has also been proactive in facilitating new technology adoption to increase spectrum efficiency and to support the growth of the wireless industry in Singapore. In July 2004, IDA introduced a Market Trial Framework (MTF) to allow companies to assess the commercial potential of new technologies, services or products by charging for their use during a trial period. A market trial licence is valid for six months and renewable for another six months. This supplements IDA's Technical Trial Framework, which allows companies to conduct technical trials of equipment in Singapore. The MTF was used successfully by a number of operators to assess the commercial viability of WBA services before applying for a full-fledged spectrum licence and an operating licence to provide the service.

In its efforts to promote wireless technology research and development, IDA has also paid particular attention to the development of Ultra-Wideband (UWB) technology. In May 2003, it launched a UWB programme aimed at bringing activities surrounding the technology to Singapore. Under the programme, industry interest in UWB is encouraged by the setting up of a UWB-Friendly Zone. Within this designated zone, developers are given significant latitude to experiment with new and innovative UWB technical designs. At the same time, IDA has also made special arrangements to provide lab space and resources on a temporary basis to companies that wish to carry out UWB-related work in the Zone. IDA has also conducted a series of UWB compatibility studies in order to gather data that would form the basis of future rulemaking on the technology in Singapore.<sup>25</sup>

### 4.4.2 Network security

Recognizing the importance of infocomm security, a major effort to boost network security on a national level was initiated by IDA under the guidance of the National Infocomm Security Committee (NISC), a



high-level, multi-agency committee that is tasked to formulate policies and strategies for cyber security at the national level.<sup>26</sup>

In February 2005, the Infocomm Security Masterplan was launched. It is a strategic roadmap that charts Singapore's national efforts to develop capabilities to prevent cyber security incidents, to protect critical infrastructure from cyber threats, and to respond swiftly to recover from actual attacks. The development of the Masterplan involved industry consultations over a 12-month period and involved a survey of more than 500 companies. The Singapore government has undertaken to invest about SGD 28 million over three years (2005-2007) in the implementation of the Masterplan.

To be implemented by IDA, the Masterplan is characterized by six areas, three of which focus on securing the people, private and public sectors by raising awareness amongst internet users about cyber threats and the appropriate security measures to take. Key initiatives corresponding to these areas include:

- launching a *National Infocomm Security Awareness Programme* involving a series of public outreach and awareness promotion activities aimed at educating home computer users on adopting security best practices and tools;
- developing a *National Authentication Infrastructure* to support secure online transactions through a trusted identification and authentication framework;
- conducting an *Infocomm Vulnerability Study for National Critical Infrastructure* to assess the adequacy of protection measures installed by network infrastructure owners and operators;
- establishing a *Business Continuity Readiness Assessment Framework* to measure the adequacy of business continuity plans of government agencies; and
- compiling an *Infocomm Security Health Scorecard* to provide an overall assessment of the public sector;

The other three strategic areas of the Masterplan represent thrusts to develop national capability, cultivate technology and R&D and secure national infrastructure. Key initiatives include:

- collaborating with local and foreign research institutes and centers to chart an R&D roadmap for the country;
- establishing a Cyber-Threat Monitoring Center, a round-the-clock facility to analyze and respond to cyber threats, by the second half of 2006; and
- creating training and certification programs for IT security professionals.

Before the launch of the Masterplan, IDA's efforts to reinforce cyber security and trust revolved around a number of initiatives that included the development and promotion of public key infrastructure (PKI)<sup>27</sup> and trust marks, human resource development in the field of cyber security and the development of security standards.

IDA's efforts in the area of PKI have included supporting the creation of a PKI Forum Singapore (PKIFS) in 2001 and spearheading the creation of an Asia PKI Forum in June 2001 to achieve international interoperability.<sup>28</sup> The efforts of the PKIFS have shown positive results with around 20 per cent of large companies in Singapore having adopted PKI as a standalone technology in 2003. More than 40,000 client certificates are in circulation, having been issued by the local public certification authority, Netrust.

In February 2001, the National Trust Council (NTC) – an industry-led committee - was formed to build consumer trust in online transactions. It implemented the 1<sup>st</sup> nationwide TrustMark Programme, TrustSG, whereby appropriate organizations, such as trade associations, chambers of commerce and businesses were accredited as Authorised Code Owners (ACO). Upon accreditation, ACOs are granted a licence to use the TrustSg seal, and they can thereafter award the TrustSg seal to merchants who adhere to their stringent codes of practice. The TrustSg seal awarded by the ACOs identifies online merchants as e-commerce enterprises that adhere to good e-business practices.<sup>29</sup>

IDA has also supported the setting up of a professional body to govern the Infocomm Security profession as well as facilitated the offering of training programmes dedicated to developing skills in cyber security. Under its Critical Infocomm Technology Resource Programme (Citrep), infocomm security administration was identified as a strategic skill with around 27 courses on infocomm security on offer.<sup>30</sup>

Through the Information Technology Standards Committee (ITSC), IDA has also supported the development of the world's first business continuity and disaster recovery (BC/DR) standards that specify stringent requirements that service providers are required to meet in order for them to provide a trusted operating environment for their end-user companies.<sup>31</sup>

## 5 SOCIAL ASPECTS OF SINGAPORE'S UBIQUITOUS NETWORK SOCIETY

With a mobile penetration rate of over 92 per cent and an island-wide distribution of 6 million RFID enabled contactless EZ-link smart cards, the distribution of networked devices has reached a high level of ubiquity among Singaporeans. Coupled with island-wide mobile network coverage, the vision of always-on ubiquitous connectivity has become a reality in Singapore. Today, connectivity is no longer limited by technology but by social convention and safety concerns, such as in aircraft and in cinemas. Increasingly, even these restrictive boundaries have been pushed back further by new technologies, redefined norms and newly recognized needs (see Box 5.1).

According to a 2004 academic survey "Singapore Youth and their Mobile Lifestyles" that was conducted on the use of mobile communications by Singaporeans aged 15 to 29 years, 68 per cent of the respondents agreed with the statement "I cannot live without my mobile phone".

### 5.1 New avenues for interaction

The ability to connect to a network at all times and from anywhere has made profound changes to the way individual Singaporeans interact between themselves and with society at large. The use of mobile phones, in particular, has offered Singaporeans new avenues and new forms of interaction and expression.

The use of SMS based services to pursue social interaction on a wide scale, in particular, have been a relatively recent phenomenon in the Singapore context. Charity fund raising by SMS, in particular, has been received with enthusiasm. Supported by all mobile operators, a large majority of publicized charity fund raising events accept donations through SMS. According to survey results, 42 per cent of mobile phone using youths have made donations to charitable organizations using SMS services.

Illustrating the growing use of mobile phones to mobilize society, the Singapore government has recently encouraged the use of moblogs – online journals posted through mobile phone – as an alternative avenue for citizens to express opinions on national issues. As a run-up to the National Day celebrations in August 2004, organizers of the national day parade provided mobile users a moblogging platform to post journals online on topics of national concern - from responsible pet ownership to the conservation of Singapore's coastline. Replies to moblogs could be posted online or sent by SMS.

On a more intimate level, the introduction of new location-based applications has also changed the way individuals interact. These include location based multiplayer games, which can locate several users within a certain radius and allow them to compete against each other, to Bluetooth based friendship services (see Box 5.2).

#### **Box 5.1: Mobile use in Hospitals**

*Singapore hospitals may allow use of mobile phones*

Following a local pilot study indicating into mobile phone use in hospitals, hospitals in Singapore may soon allow mobile phones to be used around the hospital - even in operating theatres.

In July 2004, Tan Tock Seng Hospital, a public health institution, conducted a trial on the use of mobile phones in the hospital environment. The trial involved 500 nurses and 40 doctors in its general surgery department.

The trial found that on average it took four minutes before a doctor returned a page sent to a pager. Delays were typically due to doctors being held up in wards or because they are unable to get to phone lines when they found the time to return the page. The hospital estimated that a doctor wastes over an hour, or some 86 minutes every day on responding through such inefficient communication means. According to the trial, allowing doctors to reply via calls through mobile phones or SMS would reduce those delays drastically.

Besides improving staff communication and efficiency, the trial results also showed that it was safe to use mobile phones in hospital premises. Studies showed that only 4 percent of medical devices, mainly monitors and ECG equipment, were affected when a mobile phone was in use at one metre away. Sensitive devices like pacemakers were only affected when mobile phones were used within 10 centimetres.

The study is currently ongoing and will be completed in the first half of 2005.

*Source: Tan Tock Seng Hospital*

**Box 5.2: Make new friends with Bluetooth**

*Mobile users in Singapore make new friends with Bluetooth*

Student Gracina Lim has made new friends thanks to mobile phone software that alerts her to compatible people nearby. She is an early customer of a service in Singapore called BEDD that uses Bluetooth wireless communications to scan strangers' phones for their personal profiles.

Launched in May 2004, users download the BEDD software into a compatible phone, complete a short profile of themselves and include a description of who they want to befriend, or an item they want to buy or sell. The software automatically searches for and exchanges profiles with other BEDD enabled phones that come within a 20-meter (65 ft) radius. Matched users are given each other's contact details. It relies on direct phone-to-phone Bluetooth transmissions without having to go through a central server.

Source: BEDD at <http://www.bedd.com/T>

## 5.2 User concerns

While ubiquitous connectivity has created new avenues for social interaction, the same phenomenon has also created new social concerns. Beyond worries over network security discussed in Chapter 4 above, other causes for anxiety include concerns over personal data protection and the opening up of new avenues for mischief.

### 5.2.1 Privacy and personal data protection

Singapore relies on both a common law tradition as well as statutory provisions to regulate the use of personal data. Under the general common law, confidential information may be protected under a duty of confidence. Personal information is also protected under sector-specific laws such as the Banking Act, Statistics Act, the Official Secrets Act and the Statutory Bodies and Government Companies (Protection of Secrecy) Act. There is however no overarching legislation or regulation for the protection of personal data in Singapore.

In February 2002, the National Internet Advisory Committee (NIAC), a high-level government advisory group on Internet related issues, released a draft "Model Data Protection Code for the Private Sector". Modeled on internationally recognized standards, it is a generic code that contains 11 data protection principles differentiated according to the various stages of data processing: accountability; identifying purposes; consent, limiting collection; limiting use, disclosure and retention; accuracy; safeguards; openness; individual access and correction; challenging commerce and transborder data flows. The Model Code is a voluntary code that is available for adoption by the entire private sector. The NTC, for example, has adopted the Model Code under its TrustSg programme for online businesses.

It may be instructive to highlight that IDA has also issued a set of guidelines to safeguard public interests when Internet Service Providers (ISPs) conduct preventive security scanning exercises to determine whether their subscriber's computers have been infected by Trojan or virus software. The need for such guidelines was highlighted following an incident in May 1999 when SingNet scanned 200'000 subscribers' computers without informing them. The guidelines articulate the importance of accountability and transparency when ISPs conduct scanning exercises. In particular, consent by ISP subscribers should be explicitly obtained before such exercises can be conducted. Scanning activities must be non-intrusive, and the ISP must inform its subscribers on how their privacy will be protected during such activities.

It is also instructive to note that the Singapore government has also found it important to reassure the public over privacy and personal data protection concerns regarding the widespread use of location sensitive RFID based systems that are used to manage traffic flows and public transportation. For example, in order to address personal data protection and privacy concerns regarding the ERP system, the LTA has assured the public that all ERP transaction records are deleted every 24 hours. ERP location sensitive information and vehicle ownership information are also kept in two separate databases. The system is also periodically audited by the Ministry of Home Affairs to ensure personal data protection.



**Box 5.3: Are you being watched?**

*Student films teacher berating classmate*

In 2003, a student in a Junior College in Singapore used a PDA to secretly film a classmate being given a sound scolding and later posted the video on the Internet. The postage-stamp-sized, grainy, three-minute video clip, shot on a Sony Clie handheld, showed a somewhat hysterical teacher reprimanding another student before tearing up his homework in front of the class. Several issues were raised in the ensuing nationwide debate – the reasonableness of the teacher’s outburst, the student’s behavior in filming the incident and his use of the Internet to air the case for public discussion.

While the student and the teacher received counseling on their respective behavior, the incident nevertheless necessitated a review of public policies dealing with the surreptitious use of recording devices in schools and public buildings.

*Source: Straits Times*

### 5.2.2 Anti-social and criminal behaviour

While many benefits can accrue to a country with a ubiquitous network, there also exists a darker side to the phenomenon. Old crimes have found new forms using networked devices. The use of SMS messaging to convey hoaxes or obscene and unsavoury messages have occurred periodically in the country. For example, SMS hoaxes such as those promising to give money or prizes if the user forwards the message to a certain number of other users have appeared in Singapore. In a more serious case of unacceptable mobile phone use, a man was charged with the crime of insulting a woman’s modesty when he sent 21 obscene SMS messages to a former colleague. The crime carries a punishment of up to one year’s imprisonment and a fine.

As a result of a number of reported incidences where camera phones were used to take and circulate obscene photos, camera phone misuse was singled out as a worrying development in 2003. While those cases were prosecuted on the basis of existing laws governing behaviour in public in general, the issue of privacy and the taking of pictures of people in public places without their consent was also raised. While not illegal, the acceptability of such practices is still subject to an ongoing debate in Singapore (see Box 5.3). It may be some cause for concern that in a survey on mobile phone use by youth in Singapore in 2004, 21 per cent of respondents indicated that they had used their camera phones to take pictures of strangers without permission. As a society entering into a new phase of infocomm development, it is clear that Singapore is still searching for its moral and social bearings with regard to the use of new applications and devices.

## 6 CONCLUSION

In its desire to forge a ubiquitous network society, Singapore has benefited greatly from the advanced state of development of its fixed line, wireless and mobile networks. This accomplishment owes itself in no small measure to the extensive measures taken by the Singapore government to develop the country’s infocomm economy. Its highly pro-active and involved approach to industry development must be considered as the key driver of Singapore’s journey to become a ubiquitous network society.

Singapore nevertheless faces significant challenges in its journey, particularly as new technologies and new standards emerge. As a small country, Singapore is limited in terms of market size. As a result, it is often unable to set standards for new technologies, applications and services as they emerge. Nevertheless, despite this constraint, the country has managed to wield a level of influence far greater than its size would otherwise warrant, largely through the efforts it has made to attract pioneering research and development activities in infocomm areas it deems as strategic. Other goals such as the desire to develop a strong local industrial base in the area of innovative ICT technologies will continue to present a challenge to the Singapore government and people. Given the relative success Singapore has realized with its paternalistic approach, it is likely that the country will proceed on a similar path in the development of a Ubiquitous Network Society.

- <sup>1</sup> Both SingTel and StarHub were compensated for the loss of their exclusive and duopoly guarantees in their service licenses. StarHub was compensated SGD 1.082 billion. SingTel was compensated SD 1.5 billion in 1997 and SGD 859 million in 2000.
- <sup>2</sup> The National Computer Board (NCB) was created under the National Computer Board Act to promote and develop information technology in Singapore. Its work included high-technology industrial policy.
- <sup>3</sup> An individual licence is awarded to a company based on a specific application filed by the company and approved by IDA. Such a licence may contain conditions particular to that company and may be modified by the regulator or through an application by the company. Class licences, however, are broad authorizations that apply to any company offering a particular service or set of services. Companies do not need to apply for class licences in order to offer those services. The rules and conditions that apply to each class licence are "gazetted" (published in the official government gazette) and any company that begins to provide that service is presumed to have read, understood and complied with those rules.
- <sup>4</sup> In June 2002, IDA conducted an auction for the allocation of Local Multipoint Distribution Services (LMDS) spectrum rights. At the auction submission deadline, IDA had not received any initial offers for the auction, forcing it to abandon its plan to award LMDS spectrum. In view of the poor interest shown by industry, IDA did not undertake a similar spectrum offering until February 2005.
- <sup>5</sup> Under the ITU-R Recommendation M.1034-1 for IMT-2000 3G technologies, the speed for: (a) stationary fixed services is defined at 0 km/hr; (b) pedestrian mobile services is defined at up to 10 km/hr; (c) typical vehicular services is defined at up to 100 km/hr; and (d) high-speed vehicular services is defined at up to 500 km/hr.
- <sup>6</sup> WLAN (Wireless Local Area Network) allows a mobile user to connect to a local area network (LAN) through a wireless (radio) connection (eg: within a building). The IEEE 802.11 family of standards, eg. 802.11b and 802.11a, specifies the technologies for WLANs.
- WWAN (Wireless Wide Area Network) uses various devices - land lines, microwave links, and radio waves, to service an area broader than that which can be covered by a WLAN, although typically with lower bandwidth. Examples of WWAN technologies are GPRS, CDMA-2000 and W-CDMA. WWAN technologies are often categorized into 'generations' such as 1G, 2G, 3G and 4G.
- WAN (Fixed Wide Area Network) is a fixed-line network that extends over a relatively large geographical area and enables broadband IP connectivity to a wide area public network (eg. the Internet). A user connects to the WAN through public access networks with technologies like ADSL and cable modem. The largest WAN is currently the Internet itself.
- <sup>7</sup> Details of the IDA-Intel Wireless Interworking Initiative and its key findings can be found at <http://www.ida.gov.sg> > Technology Department > IDA-Intel Wireless Interworking Initiative.
- <sup>8</sup> This figure is derived from subscribers who are actually paying for the service and not from the number of data and Internet capable handsets in the market.
- <sup>9</sup> IDA mandated SMS interoperability between operators in February 2000.
- <sup>10</sup> In November 2002, IDA mandated interoperability for MMS between operators, a first in Asia.
- <sup>11</sup> 2x60MHz of paired plus 20MHz of unpaired 3G spectrum was made available for the auction. This was divided into four blocks - with one block consisting of 2x15MHz of paired spectrum and 5MHz of unpaired spectrum, and three blocks consisting of 2X14.8MHz of paired spectrum and 5 MHz of unpaired spectrum. The specific band plan used was as follows:

Licence	Paired (MHz)	Unpaired (MHz)
A	1920-1935.1/2110.3-2125.1	1914.9-1920
B	1935.1-1950.1/2125.1-2140.1	1909.9-1914.9
C	1950.1-1964.9/2140.1-2154.9	1904.9-1909.9
D	1964.9-1979.7/2154.9-2169.7	1899.9-1904.9

- <sup>12</sup> See <http://www.muvee.com> for more information on the product.
- <sup>13</sup> See <http://www.wilabs.com> for more information on the product.
- <sup>14</sup> Radio Frequency Identification (RFID) is a wireless system that uses radio frequency communication to automatically identify, track and manage objects, people or animals. The wireless system consists of two main components, a transceiver (RFID reader) and a transponder (RFID tag). Reading and writing distances can vary from a few millimeters to several meters depending on the technology variation used.
- <sup>15</sup> The Electronic Product Code (EPC) is a standard naming scheme that uniquely identifies and tracks details of physical objects, assemblies and systems, through the entire supply chain. EPC is considered the next evolution of the Universal Product Code (UPC), found as a barcode on most products today. The UPC provides a unique identifier for every product type while the EPC provides true item-level tracking.
- <sup>16</sup> See <http://www.tunitytech.com/> for more information
- <sup>17</sup> For more information on the work of EPCglobal Inc. see <http://www.epcglobalinc.org/>.
- <sup>18</sup> RFID Focus is a start-up media and RFID resource company. It aims to promote RFID awareness and applications through various channels such as web portals, e-zines, publications, seminars, as well as RFID training programmes.
- <sup>19</sup> In addition, the Cahners-In-Stat group projected that home networking revenue derived directly from home networking hardware and the incremental value of networking connectivity on entertainment equipment will grow from \$6.2 million in 2004 to \$8.5

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million by 2008. The total value of equipment that incorporates a home networking connection will jump from \$8.3 billion in 2004 to \$17.1 billion by 2008.

- <sup>20</sup> More information on the technology applications deployed by Alexandra Hospital can be found at <http://www.alexhospital.com.sg/>
- <sup>21</sup> M2M communications systems allow users to remotely monitor and control key business processes and functions via wireless-enabled devices. Devices connect with other devices to share content such as alerts, supply chain information, digital content, facilitating a seamless flow of data and services.
- <sup>22</sup> See <http://www.radixs.com/> for more information.
- <sup>23</sup> All Arowana fish in the natural environment have been classified as endangered species and prohibited from capture and trade.
- <sup>24</sup> For more information see <http://www.speedpass.com.sg>
- <sup>25</sup> See IDA's Ultra-Wideband (UWB) Programme at <http://www.ida.gov.sg> for more details.
- <sup>26</sup> The NISC was formed to formulate policies and the strategic direction for cyber security at the national level. The high level multi-agency committee comprises representatives from the Ministry of Home Affairs, Ministry of Defence, Ministry of Information, Communication and the Arts, Ministry of Finance, DSO National Labs, and the Defence Science and Technology Agency (DSTA). IDA acts as the secretariat to the Committee.
- <sup>27</sup> A PKI refers to the whole system of policies, processes and technologies including digital certificates, certificate servers and Certification Authorities (CAs) . A CA is a trusted third party that verifies the identity of an applicant registering for a digital certificate and issues that person a digital certificate binding his or her identity to a public key. It also provides certificate management services such as publications and revocation of digital certificates.
- <sup>28</sup> For more information on the Singapore PKI Forum and the Asia PKI Forum, see respectively <http://www.pkiforumsingapore.org.sg> and <http://www.asia-pkiforum.org/>.
- <sup>29</sup> For more information on TrustSG, see <http://www.trustsg.com/>.
- <sup>30</sup> See <http://www.nicc.org.sg/> for more information on the Citrep programme.
- <sup>31</sup> See <http://www.itsc.org.sg/> for more information.