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Wi-Fi "Innovation" in Indonesia:

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Wi-Fi "Innovation" in Indonesia: Working around Hostile Market and Regulatory Conditions

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Executive Summary

With their low-cost and quick deployment time, wireless Internet technologies like Wi-Fi offer last-mile access network solutions to developing countries with limited network infrastructure. Among developing countries, Indonesia is unique for the extent of Wi-Fi that has been deployed by Internet Service Providers (ISPs) and private entrepreneurs in more than 40 towns and cities across the archipelagic nation. However, the findings from the current study finds that Wi-Fi "innovations" in Indonesia are not a result of enlightened policy designed to extend communication infrastructure to unserved areas but rather a workaround solution to hostile market and regulatory conditions.

The research objectives were to determine the conditions that gave rise to Wi-Fi becoming an access technology of choice for Indonesian ISPs; the lessons that can be abstracted from Indonesian Wi-Fi innovations; and the steps that must be taken for the next stage of Internet growth in Indonesia. Despite having two regulatory bodies, DG Postel and BRTI, the Indonesian telecommunication sector lacks credible, independent regulation. DG Postel is embedded within the Ministry of Communication & IT and BRTI is nominally independent being understaffed, lacking teeth and being chaired by a DG POSTEL representative. A poor regulatory environment is compounded by a non-competitive telecommunication sector dominated by PT Telkom and Indosat who were given exclusive licenses by the Indonesian government for fixed telephony and international gateways, respectively. In the absence of regulatory requirement to unbundle the local loop, PT Telkom's monopoly over the last mile facilities that are critical to all local telecommunications services especially Internet service means that Internet Service Providers (ISPs) needed to build their own last mile infrastructure to reach customers. However, license conditions for Network Service Providers, the category that ISPs fall into, forbid them from building their own infrastructure—last mile or backbone. The ISPs used Wi-Fi in the access network as a workaround solution for their inability to build or buy last-mile infrastructure. Until recently (January 2005), the unlicensed use of 2.4 Ghz for Wi-Fi was illegal and the use of 5.8 Ghz continues to be. However, that has not prevented ISPs from using those parts of the frequency because Wi-Fi is cheaper and easier to deploy compared to wired infrastructure and has lower sunk costs at risk if caught by the authorities. As is well documented in the literature of economics, monopolists do not invest the full amounts required for economic efficiency when they are provided with monopoly returns on their investments. This is the case in Indonesia with backbone infrastructure that is scarce outside the islands of Java and Sumatra and unevenly deployed even in those two islands. The inadequate supply of backbone and lease line infrastructure and the high monopoly prices for leased lines that exceed benchmark prices in other countries by as much as 48 times, has forced ISPs to use Wi-Fi as low-capacity backhaul networks to carry Internet traffic. These cost saving strategies by ISPs have not been able to keep retail Internet prices from being three or four times the price in benchmarked countries. This has resulted in a multi-tiered retailing of Internet service, where large customers

like schools act like ISPs using Wi-Fi to connect to neighbourhood networks, other schools and businesses to recover high Internet costs that can be as much as US$4000 per month for a 2Mb link. It is evident from the research findings that ISPs in Indonesia have used Wi-Fi "innovations" to circumvent market & regulatory barriers. Until credible regulatory reform is carried and the telecom market is liberalized, the gains in the telecom sector generally and Internet specifically will be limited and unsustainable. For quickest results for high Internet growth in Indonesia, the regulator must reduce leased line prices as a number of studies in different countries have shown.

The silver lining for Indonesia is the inherently lower costs of Wi-Fi compared to wired last-mile access technologies, providing the country with potentially explosive Internet growth if conducive regulatory and market conditions are created.

Introduction

Wireless Internet technologies provide the potential for bridging the digital divide between countries and regions that have well-developed telecommunications infrastructure and those that do not. This point is clearly illustrated by the phenomenal growth of mobile communication in countries that are otherwise poorly endowed with wired communication infrastructure. Faced with the prohibitive cost of deploying conventional wired networks in countries with large swathes of unconnected regions along with an entrenched fixed line incumbent, wireless mobile telephony became a viable option for extending communication services to those that were previously unconnected.

More so than voice telephony, the Internet has much greater potential to improve the lives of the people because it can provide an array of interactive multimedia solutions in diverse areas like government services, health information and diagnostics, education and commerce to hard to reach places outside urban centers. Typically, hard to reach places also have poor infrastructure and connectivity. It is precisely in places where infrastructure is poorly developed that wireless computer networking, particularly the IEEE 802.xx standards popularly referred to as Wi-Fi, can be a viable solution by leapfrogging some parts of the traditional wired network to connect far-flung villages to each other and to the wider world via the Internet. The fast declining costs of wireless technology along with the embedding of Wi-Fi chipsets in variety of mobile devices including mobile phones can potentially extend some form of broadband Internet connectivity to areas of the world that can only dream about it at present[1].

However, as this study will show, the challenge of bridging the digital divide has been less an issue of finding and deploying the right technologies but rather finding ways to overcome institutional, regulatory and market barriers to meet the connectivity needs of the developing world.

In the World Radio Conference in 2003, participating countries voted to allocate the 2.4-Ghz and the 5-Ghz bands for license exempt applications like Wi-Fi[2]. Nevertheless, most developing countries have not unlicensed the above bands. As can be seen on Table 1, only 41% of developing countries have regulations supporting license exempt bands compared to 96% of the developed country that allow unlicensed use of frequencies needed for Wi-Fi[3]. In the face of overwhelming benefits of Wi-Fi for rapidly extending connectivity in developing countries, as documented below, it should seem a bit

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[1] *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

[2] WRC03 Resolution 229 available at URL: http://www.itu.int/ITU-R/study-groups/was/documents/resolution229e.doc

[3] *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

perplexing as to why the developing world is lagging behind in promoting Wi-Fi enabling regulations. The reasons are not hard to fathom.

Table 1: Licensing regulations for wireless Internet in developed and developing countries		
	Developed countries	**Developing countries**
% with license-exempt wireless spectrum	**96%**	**41%**
% with license-exempt wireless devices	**95%**	**40%**
Source:UN BCS @ CeBit June 2003 in Wireless Internet Institute (2003)		

Many developing countries have yet to reform their telecommunications sector from one dominated by government operated historical monopolies to one where free competition in the supply of telecommunication services exists. Where incumbents have been partially privatized the government continues to retain controlling shares in the operator. Where a regulator has been appointed to oversee the functioning of the sector, they have been undermined by frequent ministerial interference. In countries that share the above characteristics, the market and regulatory environment are not conducive for the adoption of measures supporting license exempt bands that allow panoply of services including voice to be provided wirelessly, circumventing the legacy infrastructure of the incumbent and hence threatening its cash flow and government revenues. Incumbents who have invested over the years in a wired infrastructure are hostile to any "disruptive" technologies that can loosen their hold over bottle-neck facilities, for example, that provide last-mile connectivity and access[4].

A study conducted in Africa found that the use of unlicensed spectrum is less restricted in African countries that enjoy a higher degree of competition in the telecommunications market compared to countries with less competition in their local and long distance markets[5]. The survey found that 37% of the countries that responded were using wireless technologies in the license exempt bands for providing backhaul network connectivity in rural areas. However, in the majority of cases where countries were imposing restrictions on the use of unlicensed spectrum they had lower competition in

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[4] *Ibid*.

[5] Wireless Networks for the Developing World: The Regulation and Use of License-Exempt Radio Bands in Africa
by Maria Isabel A. S. Neto Licenciatura in Eletrotechnical Engineering Instituto Superior Técnico, 1997

their local and long distance markets. The study concluded that countries with restrictive regimes were using them to protect the market power of incumbent and to keep the barriers to entry high.

Therefore it is not surprising that a significant number of developing countries that are in the early stages of the telecom reform process and could benefit most from the "leap-frogging" capabilities of wireless technologies have been slow to adopt new regulations supporting license exempt bands. A combination of regulatory barriers and the unwillingness of policymakers to jeopardize the revenue of the government owned operators have been the biggest stumbling block. Ironically, as we shall see in the case of Indonesia, it is precisely because of these regulatory, policy and market barriers that Wi-Fi has proliferated and flourished in that country.

Wi-Fi Technology Background

In the world of rapidly evolving information and communication technologies (ICTs), regulation is often seen as lagging behind or at worst a hindrance. Wi-Fi, a wireless broadband technology, which is one of the greatest successes of the ICTs industry in recent times, has ironically developed thanks to regulatory foresight and initiative. In 1985, the Federal Communications Commission (FCC), the US telecommunication regulatory body, unlicensed three bands of spectrum at 900Mhz, 2.4Ghz and 5.8Ghz that could be used by individuals and entrepreneurs without obtaining a government license. It was unheard of at that time to have unlicensed spectrum with the exception of ham-radio channels[6].

Although, the bands are license exempt the FCC has imposed rules limiting the power and other technical properties that a radio operating in the bands can use. It is expected that if users stay within the lower power specification they can use such bands either without mutual interference or by managing any interference among themselves without governmental legal help. Most countries that have currently unlicensed the Wi-Fi range of frequencies have generally also issued similar rules.

From the time FCC unlicensed the "garbage bands[7]," it took industry more than 10 years to agree on a basic specification and to develop a common wireless standard that would allow wireless equipment manufactured by different vendors to talk to each other. But once the standard was published in 1997, vendors developed Wi-Fi equipment prototype around two variants of the 802.11 standard: 802.11b (operating in 2.4Ghz band) and 802.11a (operating in 5.8Ghz band) by early 2000. Newer variants of the

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[6] Historical account broadly based on "A brief history of Wi-Fi", *The Economist,* June 10, 2004.

[7] The 2.4 Ghz band was referred as garbage bands because it was allocated to noisy equipment like microwave ovens and communication was possible only with the development of spread spectrum technology that spread the radio signal over a wide frequency range.

802.11 standard were developed over time offering higher bandwidth for data transmission as can be seen on Table 2.

Table 2:

Family of Wi-Fi Standards			
Standard	**Speed**	**Frequency Band**	**Compatible with**
802.11b	11 Mbit/s	2.4 GHz	b
802.11a	54 Mbit/s	5 GHz	a
802.11g	54 Mbit/s	2.4 GHz	b, g
802.11n	100 Mbit/s	2.4 GHz	b, g, n

Source: Adapted from Wi-Fi versus Wimax, Mahinda Herath, 2005.

Among the first Wi-Fi consumer products to hit the market was Apple Computer's laptop equipped with a Wi-Fi card under the brand name Airport. Wi-Fi was mainly used inside the home as a wireless local area network (WLAN) that connected other computers and peripherals like printers to each other. The "hotspot" or wireless coverage extended to a maximum of 50 meters with a significant drop-off in data transmission speed moving away from the Wi-Fi access point. Once other computer makers, led by Intel, put their weight behind mobile computing and the Centrino processor, Wi-Fi use took off. Currently, more than 90% of notebook computers produced are Wi-Fi enabled[8]. Annual unit sales of Wi-Fi chipsets have been growing by an average of 64% over the last six years, topping 120 million chipsets for the year 2005[9].

The European Commission (EC) played a significant role in harmonizing regulation among member countries regarding license-exempt bands. In March 20, 2003, the EC issued a recommendation to encourage member states to provide license-exempt WLAN access to public electronic communications networks and services in the available 2.4-

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[8] "More than 120 million Wi-Fi Chipsets Shipped in 2005," Wi-Fi Alliance press release, November 28, 2005.
[9] *Ibid* 2.

Ghz and 5-Ghz bands[10]. Although this recommendation is not binding on member states, it is consistent with the (binding) Authorization Directive, which requires all member states to allow license-exempt access to the spectrum when the risk of harmful interference is negligible. Because of this and subsequent initiatives, most EC member states have expanded the number of license-exempt bands for Wi-Fi[11].

Although Wi-Fi use in the developed world has been primarily used for home networking, there has been a growing number of "hotspots" that have sprung up in coffee-shops, airports and other public spaces that provide wireless Internet connectivity for a fee. There are an estimated 100,000 public Wi-Fi hotspots globally and this market is expected to grow at an estimated compound annual growth rate of 57% next couple of years[12]. Europe has 42% of the world's public hotspots, followed by Asia Pacific 32% and North America 26%. Korea Telecom is the world's largest public Wi-Fi operator having 13,412 hotspots at the end of 2005[13].

The last two years, has seen a number of initiatives in the USA and in Europe, where municipalities have invested in wireless infrastructure to provide city-wide broadband Internet access or have tied up with ISPs to provide the service for free or at a price lower than the available retail price. The city of Philadelphia is a much cited example, which has closed a major contract with Earthlink to provide Internet connectivity to city residents covering an area of 135 square miles at prices lower than ADSL or Cable prices[14]. A number of cities in California, including Anaheim, Cupertino, San Francisco, Santa Clara, have either free or low priced access to wirelessly delivered broadband Internet. As the pros and cons of municipalities getting into the ISP business is currently being debated[15], federal and state lawmakers in the US are considering legislations that would limit or ban such initiatives[16].

The potential of Wi-Fi in developing countries goes beyond the home and urban centers by offering the possibility to bridge the significant communication infrastructure gap that exists between rural and urban regions. The very features that make it popular in developed countries also make Wi-Fi an attractive technology for bridging the digital

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[10] Available at:
http://europa.eu.int/rapid/start/cgi/guesten.ksh?p_action.getfile=gf&doc=IP/03/418|0|RAPID&lg=EN&type=PDF

[11] "Commission frees up frequencies for Wi-Fi," Available at:
http://www.euractiv.com/en/infosociety/commission-frees-frequencies-wifi/article-142740

[12] "The Wi-Fi hotspot market is still in its infancy, concludes an IDC study," www.wi-fitechnology.com, 19 June, 2003.

[13] "Global Wi-Fi hotspot coverage approaching 100,000," by John Walko, *EE Times*, 26 September 2005.

[14] Municipal Wi-Fi catches on in US cities," Carmen Nobel, *E-week*, Feb 1, 2006,
http://www.eweek.com/article2/0,1895,1917896,00.asp

[15] On going discussion at: http://www.lirneasia.net/2005/02/government-supply-of-wifi-in-competition-with-private-suppliers/

[16] "Battle over municipal Wi-Fi network," Dibya Sarkar, *Federal Computer Week*, August 18, 2005. Available:
http://www.fcw.com/article90139-08-18-05-Web

divide: its ease of set-up, use, and maintenance; its relatively high bandwidth; and, most importantly, its relatively low cost thanks to the high demand for Wi-Fi equipment in the developed world that has brought down unit costs dramatically for both users and providers[17]. Wi-Fi routers and cards, used to create a wireless network, retail below $80 each. Using antennas and repeaters, it is possible to extend the range of a Wi-Fi connection from 50 meters up to 20 kilometers[18]. With this kind of range and low deployment costs, Wi-Fi technology opens up new possibilities for providing rural connectivity. In one "wireless" leap, Wi-Fi offers countries the opportunity to connect regions that currently lack wire line infrastructure; it can also leap-frog difficult terrain to provide cost-effective connectivity to farmers, traders, and fishermen who live outside of urban centers. Not only are Wi-Fi networks significantly cheaper than wired networks, but wireless technology obviates the hassle of obtaining permits and digging land for laying cables.

Along with its obvious advantages, Wi-Fi has a number of limitations. Since it is an unlicensed band, it is prone to interference from other Wi-Fi networks in the vicinity and other devices like Bluetooth, cordless phones, microwave ovens etc. that use the same frequencies. Interference degrades network performance and affects reliability of the service. Furthermore, there is a steep range/bandwidth trade-off as speed of data transmission drops the further it travels from the wireless access point. For the above reasons, Wi-Fi cannot provide carrier class reliability that one expects from a fiber optic or even a microwave link that transports data at high speed and over large distances with little degradation in network performance. It is precisely for this reason that Wi-Fi by itself cannot be a connectivity solution for an entire country. It still requires a link to a high-performance fiber optic backbone that connects to the national network and to the rest of the world. At best, Wi-Fi is effective as an access network for providing last-mile connectivity and as a low-capacity, backhaul network for carrying data over 5-10kms, as cases from around the developing world show.

Wi-Fi Deployment in Developing Countries

A study by the Wireless Internet Institute has show-cased a number of pioneering efforts to bridge the digital divide using wireless broadband in developing countries[19]. Some of these cases are featured below along with additional instances where Wi-Fi plays a role in providing Internet connectivity to countries where wired alternatives are simply not available.

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[17] *A Road To Universal Broadband Connectivity,* Alex Pentland, Richard Fletcher, Amir A. Hasson, 2002. Available: http://www.itu.int/council/wsis/080_Annex4.pdf

[18] *Ibid*

[19] *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

Macedonia

Macedonia is one of the few developing countries with extensive Wi-Fi deployment on a national scale. Macedonia Connects project funded by the US Agency for International Development (USAID) has brought broadband internet access to hundreds of remote villages in Macedonia by connecting all of the country's 460 primary and secondary schools with broadband wireless[20]. When a school is wirelessly connected, the surrounding village also has the benefit of Internet access. Using Macedonia's mountainous terrain to its advantage, the network uses mountains as distribution points for reaching the surrounding villages.

The Macedonian government saw affordable access to the Internet as a way to stimulate the economy and create new jobs and entrepreneurial activity. However, the challenges that Macedonia faced in reaching this goal, are similar to ones many developing countries are faced with. Access to the Internet is dominated by the country's former state-owned monopoly, Makedonski Telekomunikacii, known as Maktel. Because of its control over the access and backbone network, Maktel was able to limit competition from rival Internet service providers that depended on the wireline infrastructure of the incumbent to provide Internet connectivity to customers[21]. According to analysts including the telecom regulator, the government's desire for fair competition was undermined by the substantial revenue it was receiving from Maktel, more than $51 million in 2004[22].

In 2005, the government introduced a law that allowed competition in the provision of Internet service. However, the high leased line prices that Maktel charged ISPs spurred the creation of Macedonia's new wireless network. USAID paid $2.5 million to provide connectivity to public schools. "We're paying for internet services in schools for two years, and because we did that the local ISP, which was chosen through the competitive process, was able to build out this network[23]," said Leigh Shamblin of USAID. "What we did is build our own backbone network across the country, and last mile access to overcome that situation." The creation of the wireless network in Macedonia, bypassing the existing wired infrastructure of Maktel, provided access at a substantially lower cost compared to the incumbent. "One of the benefits of the Macedonia Connects project is that pricing for broadband connectivity went from nearly €120 to €23 per month due to the creation of a separate networking infrastructure completely independent of Maktel," said Glenn Strachan, the director of Macedonia Connects[24]. Maktel was forced to cut its prices to compete.

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[20] "Macedonia leads world with Wi-Fi," David Reid, BBC Website, Nov 11, 2005.
[21] "Macedonia seeks affordable ways to log on," Nicholas Wood, *International Herald Tribune*, April 4, 2006.
[22] *Ibid.*
[23] *Ibid.*, 14
[24] *Ibid.*, 15

Macedonia's case may be difficult to replicate in other developing countries that have similar entrenched interests but no seed-money, as provided by USAID, to deploy a wireless network nationally. It is also not clear, whether the schools can afford to pay for Internet access at the end of two years when USAID funding comes to an end.

South Africa[25]

The story of UniNet Communications of Cape Town has many parallels with what ISPs in Indonesia have gone through, as will be explored in greater detail below. Although UniNet's goal is to provide affordable last-mile connectivity to homes and small businesses, it has started out by providing service in lucrative areas in Cape Town and Mozambique to become financially viable before going into high cost areas. However, in both markets in Mozambique and South Africa, where it operates, UniNet faced the brunt of the regulatory agencies that have gone to the extent of seizing its equipment to stop its operations. According to the CEO David Jarvis, "The big state-owned telecommunications companies are still trying to keep their monopoly," and since the rules and regulations governing Wi-Fi are not clearly defined, "this is generally used to help protect the existing monopolies." The National Institute of Communications, the regulatory agency in Mozambique had told UniNet to suspend all services on the 2.4 GHz band. UniNet continued its operations because the regulation in this area was not clearly defined. The South African regulatory body, the Independent Communications Authority of South Africa, or ICASA, was far more organized in its response. After repeatedly threatening to close down its operations, ICASA confiscated UniNet's equipment. The biggest barriers to deployment of wireless Internet service are the regulatory agencies, according to Jarvis: "The main barrier at the moment is the regulatory authority, a clear understanding of the legal framework, and the attitudes of the local regulatory authority are crucial."

The regional regulatory body TRASA (The Telecommunications Regulators Association of Southern Africa) is unambiguous in urging the southern African governments to change their regulations to create conducive environment for promoting access to wireless technologies for development[26]. Although, TRASA encourages license-exempt access to the 2.4 GHz and 5 GHz bands by recognizing that WiFi can play a substantive role in increasing access to opportunities in Africa, it is evident from the behavior of the regulatory agencies in the region, that entrenched interests of the historical incumbent is paramount compared to the benefits of affordable access to the unconnected.

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[25] "WISP on the edge," page 63, in *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

[26] *Guidelines on Wireless Policy and Regulations* Available here: http://africa.rights.apc.org/index.shtml?apc=ie_1&x=31332

Rwanda

First Mile Solutions (FMS), which has patented the "store-and-forward[27]" system which has been used in India in the DakNet project, has basically deployed variations of this technology in a number of countries including in Rwanda. Working with e-ICT, a local NGO and the local telecom operator Artel, FMS has set up a number of network hubs in the capital city Kigali that connect wirelessly to a truck that provides store-and-forward access to the surrounding villages. Although the villages connect to the Internet asynchronously, in Kigali, real-time Internet access is available via the hubs. Along with deploying the technology, FMS also imparts training to the local technical team in order to ensure sustainability of the project when FMS technicians windup their support.

Malawi[28]

Africa-Online, an ISP based in Blantyre, Malawi, has provided broadband Internet access using wireless infrastructure for more than three years. Seventy-percent of Africa-Online's customers are corporate customers who are connected to the access network wirelessly. Connection to the Internet backbone is via satellite. Because of the enormous costs for international bandwidth, the ISP has focused its operations in commercially viable areas, meaning in commercial centers in Blantyre and Lilongwe. According to Africa-Online CEO Paul Shaw, reliable high speed Internet access to the commercial and banking sectors have boosted investor confidence and has increased the productivity of export-oriented businesses. The company is commercially viable because it has restricted its operations to lucrative, urban areas to recoup its high bandwidth costs that are about 100 times that of US or European prices. With prices that high, extending access to high cost rural areas would have probably been fatal for the ISP.

India

One of the earliest experiments of Wi-Fi technology in a developing country context was the DakNet project funded and developed by MIT's Media Lab. The DakNet project has provided asynchronous Internet connectivity in a few villages in Karnataka and Harayana.[29] DakNet is a wireless communication system that fixes Mobile Access Points on vehicles that exchange data wirelessly with Wi-Fi enabled kiosks in villages that the vehicle passes through. After making its rounds through the villages, the vehicle returns to a hub and uplinks the data collected to the Internet backbone[30]. Communication takes place asynchronously using the "store-and-forward" system making services that rely

[27] http://www.firstmilesolutions.com/

[28] "Slow Incubation success," page 53, in *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

[29] http://www.firstmilesolutions.com/projects.php?p=rw-dk

[30] *DakNet: Rethinking connectivity in developing nations*, A. Pentland, R. Fletcher and A Hasson, 2004. Available: http://www.firstmilesolutions.com/documents/DakNet_IEEE_Computer.pdf

on real-time data transfers including voice over IP and web browsing difficult. Although the costs of the system are relatively low, it has not been adopted widely in India.

The Indian government's decision to de-licence the 2.4 GhHz and 5.1 GHz bands for both indoor and outdoor use in 2005, has spawned a number of articles in the media that have proclaimed the impending "Wi-Fi revolution" in India which will take the country by storm. The reality is that much of the existing and planned Wi-Fi deployment in India is predominantly in the cities—in airports, coffee houses and five star hotels[31]. As per Frost & Sullivan estimates there were 300 public 'hotspots' in India at the end of 2004, of which 80 per cent were in Bangalore. According to some analysts this is set to cross the 1500 mark by the end of 2005[32]. For a country the size of India's, Wi-Fi coverage is not only negligible but its potential for bridging the urban-rural infrastructure gap is a long way from being realized.

Cambodia

In Cambodia, FMS has deployed Wi-Fi based store-and-forward system on motorcycles in 2003. "Internet Village Motormen" on five motorcycles equipped with a Mobile Access Points, go around 15 solar-powered village schools and telemedicine clinics in a remote province of Cambodia to provide asynchronous email and web access via a 256Kbps satellite uplink. The approximate cost per village to set up the system was $500; though the recurring costs of satellite connectivity is not mentioned. The project was financed by American Assistance to Cambodia and the World Bank.

Mexico[33]

Baja Wireless, as its name suggests, is a wireless ISP that provides broadband Internet connectivity to residents of the city of Ensenada in Mexico, located 65 miles south of San Diego. This ISP is targeting residents in medium sized cities that do not have wired telephone service due to backlogs or who need faster Internet access. Although Baja Wireless had set an ambitious plan to connect about 30 cities in the next 30 months in 2003, it has only managed to connect two so far. Baja Wireless offers different packages for clients based on their bandwidth usage, though the cheapest residential package starts at about $30 per month.

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[31] "Wi-Fi takes off across India," Tamanna Kumar, *Telecom Asia*, March 17, 2005. Available: http://www.telecomasia.net/telecomasia/article/articleDetail.jsp?id=150789

[32] *Ibid*.

[33] "Making it at the margins," page 57, in *Wireless Internet opportunity for developing countries*, Wireless Internet Institute (Eds.), 2003. URL: www.w2i.org

Assessing Wi-Fi Deployment in Developing Countries

In most cases, except Macedonia, the geographical coverage of Wi-Fi deployments did not extend beyond a handful of villages or urban areas. In countries where FMS's store-and-forward system has been deployed, they were made on a small-scale, experimental basis, in most cases with donor funding. Delicensing of the Wi-Fi frequencies has seen a sharp growth of wireless hotspots in India due to private investment. However, growth of Wi-Fi deployment in India remains concentrated in a few urban centers and the benefits of wireless technologies are still to be leveraged in a significant manner for rural access. Although, regulatory and market barriers have stymied deployment of wireless technologies in Africa, even if enabling regulation allow unlicensed use of the Wi-Fi spectrum, it seems unlikely that entrepreneurs are going to go in a hurry to rural areas unless the underlying factors for high cost of domestic and international leased lines and bandwidth are addressed.

In countries where incumbent operators are monopoly suppliers of fixed line infrastructure it is difficult to achieve a level playing field for the provision of Internet service if the incumbent is also an Internet Service Provider (ISP). Typically, ISPs lease lines from telecom operators to connect to the Internet backbone or to reach customer premises. When the sole provider of leased lines is the incumbent monopoly, the competitive ISPs are at a significant disadvantage. ISPs operating in such an environment are often faced with significant barriers when they are denied access to leased lines or are "price-squeezed" with high leased line and bandwidth prices that raises their input costs and make their services commercially unviable. In the absence of a clear regulatory framework either supporting competition in telecom sector or providing an access regime, access to an Internet backbone may be either impossible or cost-prohibitive for competitive ISPs.

Among developing countries, Wi-Fi "innovations" in Indonesia is unique not only because of the extensive deployment of this technology to a large geographical area but also because this innovation came about because of endogenous factors rather than external donor aid or technical input from organizations like FMS. Although regulatory environment and market structure played an important role, as they also did in South Africa, civil society significantly shaped the manner in which Wi-Fi services developed in Indonesia, as will be explored in greater detail in the next section.

Overview of Indonesia

Indonesia is the world's largest archipelagic state with more than 17,000 islands that stretch from the Indian Ocean to the Pacific Ocean[34] spanning 5,150 kilometers. Among the major inhabited islands are Java, where 60% of Indonesians live, Sumatra, Kalimantan, Sulawesi and Papua. Out of a total area of 9.8 million square kilometres, 81 per cent is sea. This physical characteristic poses a challenge in rolling out communication infrastructure to thousands of islands spread over a large area, as can be seen on

Figure 1: Map of Indonesia

Figure 1. Along with the challenges of extending physical infrastructure is providing communication services to 241 million inhabitants of Indonesia, the fourth most populous country in the world.

Wi-Fi Deployment in Indonesia

Wi-Fi deployment in Indonesia is unlike any of the cases outlined in developing countries in the previous section. As early as 1996, before common standards for wireless local LAN were developed, Indonesian ISPs were using wireless links for backhauling their data[35]. Long before the 2.4 GHz band was delicensed in Indonesia, Wi-Fi was deployed in more than 40 towns and cities in the different islands[36]. In interviews with representatives from INDOWLI (Indonesian wireless Internet community),

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[34] CIA Factbook: http://www.cia.gov/cia/publications/factbook/geos/id.html

[35] Personal communication by Simanjuntak, APJII meeting August 19, 2005, Jakarta, Indonesia.

[36] Personal communication by Augustine, Michael Sunggiardi, Meeting with INDOWLI, AWARI, APKOMINDO, August 18, 2005, Jakarta, Indonesia. The following are some of the towns in Indonesia with Wi-Fi service: Sumatra- Aceh, Medan, Jambi, Bengkulu, Pekan Baru, Batam, Palembang, Lampung; Java-Jakarta, Bogor, Bandung, Cirbon, Semarang, Yogya, Solo, Magelang, Salatiga, Surabaya, Malang, Kediri, Madiun, Mojokerto; Kalimantan-Pontianak, Banjarmasin, Palankaraya, Samarinda, Balipapan; Sulawesi-Makasser, Manaddo, Palu, Gorontalo, Kandari; Maluku-Ambon; Papua-Jayapura, Timika, Manokwari; Bali-Basar.
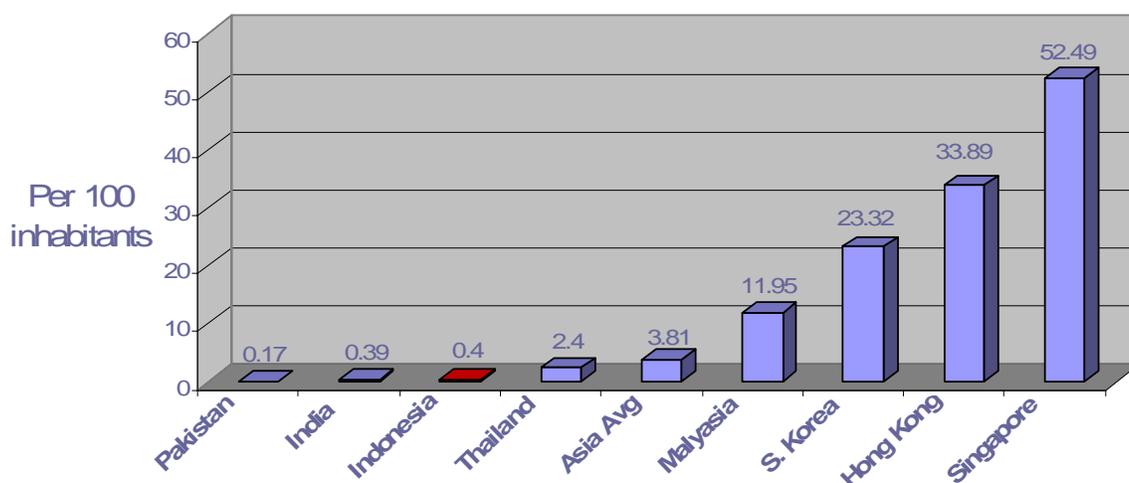
APKOMINDO (Association of Computer Businesses), and AWARI (Association of cyber café), the geographical coverage of Wi-Fi was estimated to be approximately 60 per cent in Java, 30 per cent in Sulawesi, 35 per cent in Sumatra and 5 per cent in Papua. Not only is the Wi-Fi coverage more than most developing countries in absolute and relative terms, they have been funded by private investment from small entrepreneurs. It is the small and medium sized ISPs rather than the big telecom operators who have invested in wireless networks.

With the objective of abstracting relevant lessons from the Indonesian Wi-Fi innovations that could be replicated in other developing countries, this project started out with the following research questions:
- Why does Indonesia have more Wi-Fi deployed to connect to the Internet than most developing countries?
- What lessons can we learn from WiFi innovations in Indonesia for other developing countries?
- What steps must be addressed for hastening Internet growth in Indonesia?

The advantages of Wi-Fi in providing cost-effective connectivity by "leap-frogging" either difficult terrain or regions with no wired infrastructure have been documented in the earlier sections. Based on the above rationale and from the evidence of extensive Wi-Fi deployment in Indonesia, one would expect Internet penetration and growth to be high in Indonesia. But the evidence presented on Figure 2 seems to indicate otherwise.

Figure 2: Internet Penetration Asian Peers

Internet Subscribers 2003

Per 100 inhabitants

| Pakistan	India	Indonesia	Thailand	Asia Avg	Malaysia	S. Korea	Hong Kong	Singapore
0.17	0.39	0.4	2.4	3.81	11.95	23.32	33.89	52.49

Wi-Fi deployment in Indonesia has not led to higher Internet penetration, compared to other developing countries. Not only is Internet subscriber base in Indonesia significantly lower than its ASEAN counterparts, it is also lower than the Asian average. When compared to a country like India, which is also large in size and population and with similar Per Capita Incomes (Indonesia $3500, India $3100, PPP adjusted), Internet growth rate in Indonesia is also lagging behind, as can be seen from Figure 3. Between an eight-year period from 1998-2005, Indonesia's Cumulative Average Growth Rate (CAGR) was 35 per cent compared to India's 58.4 per cent during the same period.

It is evident that regulation or policies designed to leverage the low-cost and leap-frogging capabilities of Wi-Fi for achieving greater access did not play an important role in the selection of the technology. In fact, until recently, Wi-Fi deployment was illegal in Indonesia which rules out government or the regulator's role in promoting this technology. The anomaly can only be explained by looking at the context within which Indonesian ISPs deployed Wi-Fi.

Figure 3: Indonesia-India Internet Growth
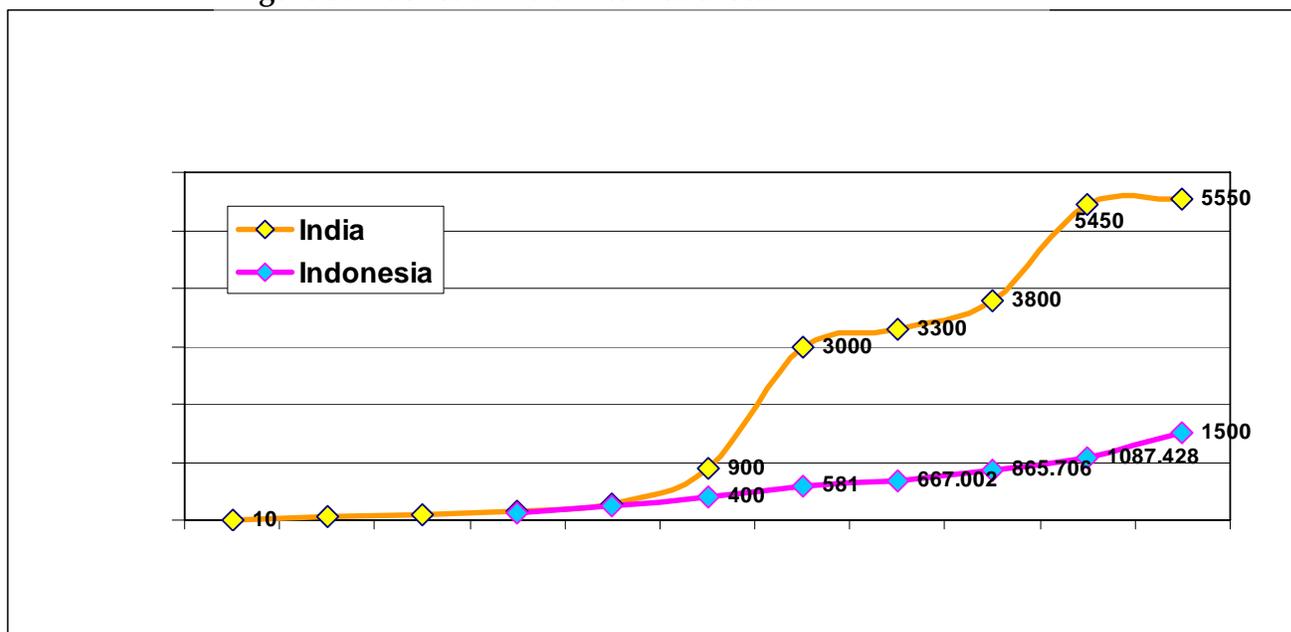
Development of Internet in Indonesia

The Internet in Indonesia from the beginning till date has been largely driven by private/non-governmental initiatives[37]. The Bandung Institute of Technology and the University of Indonesia established the first link to the Internet using international direct dialling.

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[37] The following section is based largely on the background paper prepared by Johar Allen, available at: http://www.iix.net.id/library/Iix_history.pdf

The first ISP, Indonet established in 1994, provided free Internet access to anyone with a modem[38]. In 1995, the Indonesian government started issuing internet service licenses and the first commercial operation was started using Indosat's submarine cable connecting to Sprint (USA) and SingTel (Singapore). By 1997, the list of ISPs had grown to 45 and the ISPs formed the Association of Internet Service Providers Indonesia (APJII). Currently, there are 124 ISPs that hold license to provide Internet service although there are estimated to be 54 additional ISPs or 30% of the total who operate without a license[39].

The largest cost component of Indonesian ISPs was the cost of connectivity to the international backbone and the local leased line access to Indosat's network. These expenses contributed 60-80% of an ISP's total monthly cost. Heru Nugroho, former Secretary General of Indonesian Internet Service Provider Association (APJII) estimated that on an average, ISPs spend about $50,000 for international internet bandwidth fee per year before the Internet Exchange was established.[40] According to him, for ISPs in other countries, bandwidth and networking costs typically represent 25% of their total costs.

The high cost of international bandwidth was further exacerbated by the lack of a national Internet exchange. Each of the 35 ISPs had separate international connections and were responsible for the 1/2 circuit cost to Indosat, the incumbent international gateway provider and ½ circuit cost to the US in order to reach the Internet backbone. Because of this, local traffic had to be routed through international channels and after a number of hops came back to Indonesia. The government's initiative to rectify the local bandwidth and connectivity issues was stalled when the East Asian economic crisis hit Indonesia in 1997. The government agreed to let the Internet association take the lead in building Indonesia's Internet backbone[41]. Led by APJII, a task force was created to develop an Indonesian exchange for local Internet traffic that was put into operation in 1997.

Theoretically, ISPs could connect from their point-of-presence (POP) to the Internet Exchange (IIX) by leasing a line from the incumbent. However, in 1997 neither fiber based leased lines nor 128 Kbps lines were made available by Telkom, the incumbent fixed line operator,[42] to ISPs. Furthermore, Indonesia's licensing framework disallowed anyone other than the incumbent from building communication infrastructure. In the absence of both build and buy options, ISPs and other end-users like cyber cafes and corporate customers started using the 2.4 GHz and 5 GHz bands as leased lines. Even

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[38] Ibid 10.

[39] *Internet Users Reach 10 Million*, 19 August 2004, Bisnis Indonesia.

[40] *PJI Spend IDR450 Billion for Foreign Bandwidth*, 8 January 2004, Bisnis Indonesia.

[41] *Indonesia Is Struggling To Get Up to Speed On Internet Technology*,
by Jeremy Wagstaff, 2 March 1999The Asian Wall Street Journal.

[42] Personal communication by Johar Allen, IDC meeting, August 19, 2005.

though this was illegal, the relatively low-cost of wireless infrastructure meant that the exposure to risk, like confiscation or closure of the network, was also low. Wi-Fi deployment was born out of necessity rather than by choice. When leased lines were made available by Telkom, the prices were so elevated that ISPs decided to continue using the Wi-Fi frequencies even though it was illegal to do so. Wi-Fi was used in Indonesia as a backhaul link to carry data over long distances and also as a last-mile access network to reach customers.

Wi-Fi "Innovation" in Indonesia

The typical ISP network can be divided into an access and infrastructure network, as can be seen in Figure 4[43]. In the infrastructure network, ISPs are connected to each other (peers) via a fiber backbone for exchanging traffic and to connect to a higher tier ISP to link to the Internet. From their points-of-presence (PoPs), ISPs may either use twisted copper pair, coax or fiber optic cable to connect to the kerb and the last meters to the customer premises is typically via a twisted copper pair or coax. The end service that is delivered may be dialup, ADSL or Cable-based Internet. Typical usage of Wi-Fi would be at the edge of the network, as a wireless residential network with a limited foot-print.

Figure 4:

Typical ISP Network

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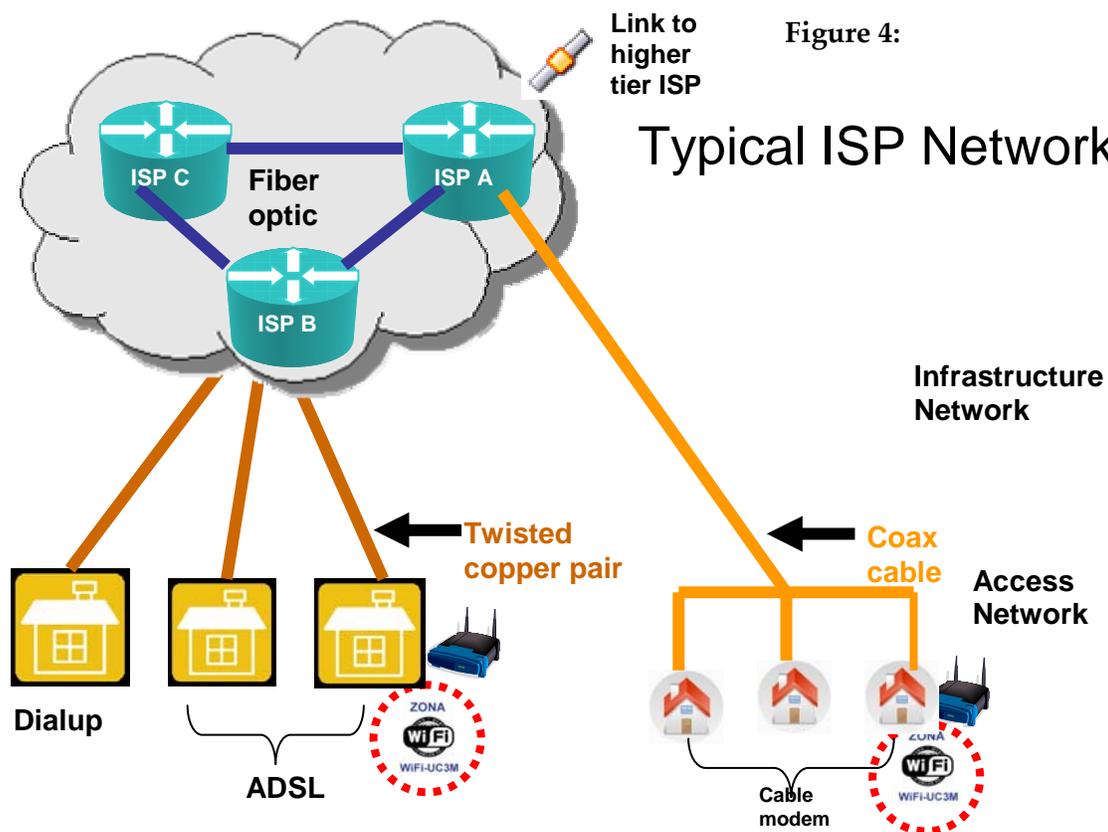
[43] *ISP Survival Guide*, G. Huston, Wiley Publishing, New York, 1999, p. 101.

The network architecture of an Indonesian ISP is however, atypical, as can be seen in Figure 5. The ISPs peer traffic to each other via an Internet exchange which they are connected to using a variety of methods, including Ethernet, microwave leased line or via Wi-Fi. Wi-Fi, especially at the 5 GHz band, which continues to be licensed and hence less prone to interference, is used (illegally) in the infrastructure component of the network to haul traffic from the ISPs' PoP to the kerb. From the kerb, the ISP may link wirelessly to a large customer like a school or a cyber café using 2.4GHz.

For providing Internet service to neighbourhood networks that connect individual houses, ISPs typically use an UTP (Unshielded Twisted Pair) cable to wire the homes, because of the costs savings from using an Ethernet card with the wired option instead of the more convenient but more expensive Wi-Fi access card.

Figure 5:

Network Characteristics-Indonesia
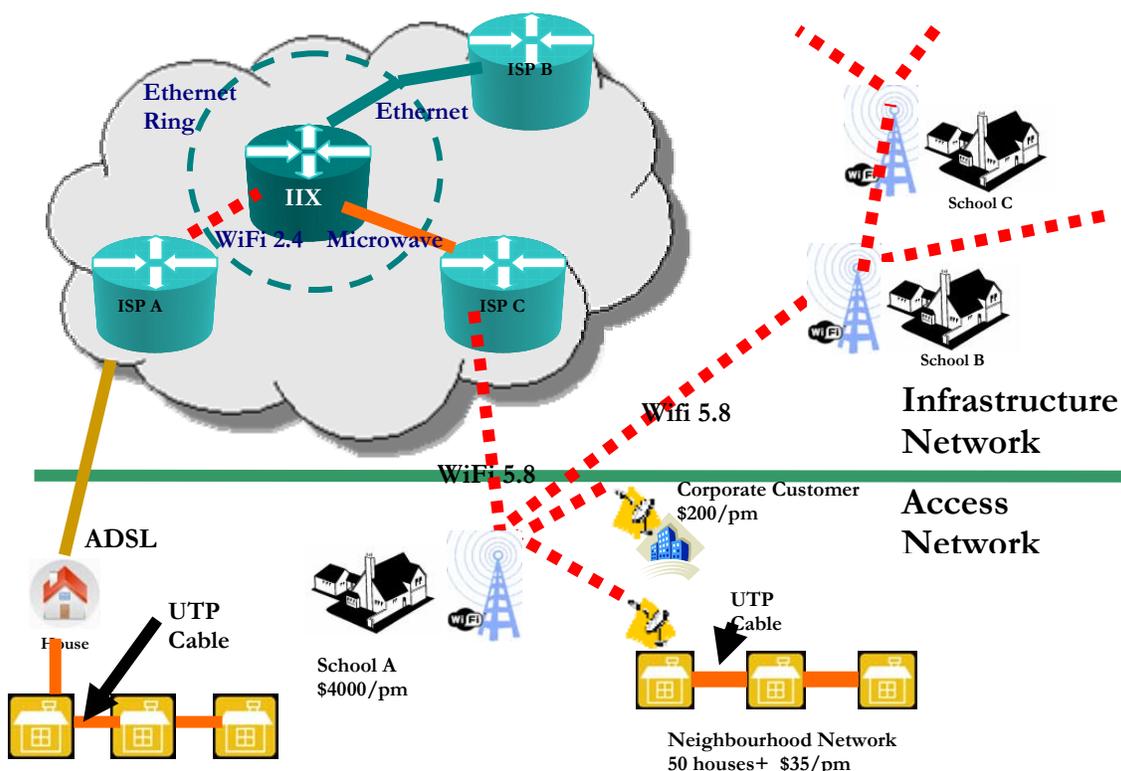
But the atypical Indonesian network does not stop here. Large customers like schools for example with a 1Mb Internet link, will in turn become an ISP by connecting to other schools, corporate customers and neighbourhood networks. This many-tiered retailing of Internet service is necessary to recoup the high retail prices for Internet access. This also explains why more than a third of ISPs operating in Indonesia, do so without a license.

A number of factors make Wi-Fi deployment in Indonesia unique. Unlike in the West, Wi-Fi is not deployed primarily as a network for the home but is rather used in the last-mile of the access network as a substitute for leased lines. There is also a blurring of the access and infrastructure network as the wireless link is deployed as a low-capacity backbone to carry data over large distances. Reversing common wisdom, the ISPs use aerial cable for providing connectivity to homes rather than Wi-Fi because it is cheaper to deploy the former. Finally, because of the low-cost and ease of setting up a wireless network, anyone can become an ISP, especially when exorbitantly high retail prices need to be recouped.

A business customer for dedicated Internet access typically pays about $4000 per month for a 2Mbps link to the IIX and a 512 Kbps international link to the Internet backbone. In order to recoup this high cost, a business customer interviewed for this study, became an unlicensed ISP and provided Internet service to 129 customers that included five schools, 20 Internet cafes, and neighbourhood networks consisting 104 homes.

For Internet service, each school was charged $100 per month, a cyber cafe $200 per month, and the individual houses around $35 each. In this instance, not only was the business customer able to cover its costs comfortably but in terms of customers, it was a larger ISP than the licensed upstream provider!

An interview with officials from a vocational school located in a suburb of Jakarta revealed that cost-recovery was not the only motive that was driving the "daisy-chaining" of Wi-Fi networks. Along with Internet connectivity, the school was also providing training and sharing its know-how on setting up ICT infrastructure and developing online content. Their stated objective is to bridge the digital divide in Indonesia by providing ICT education and affordable Internet access to schools and communities. The School Information Network (SIN) initiative, led by this particular vocational school, aims to connect all schools around Jakarta to a wireless ring by 2006. They have been training 200 teachers every year from different parts of Indonesia with a view of replicating their model of know-how bundled with affordable ICT access in other provinces.

Most schools are insulated from crackdowns by the Indonesian telecom ministry and the police for providing Internet service and for using the 2.4 GHz (when it was unlicensed) and the 5 GHz band without a license. The Ministry of Education is supportive of the efforts by schools to create a wireless school network that provides affordable Internet access. The Ministry also provides funds to schools for training other teachers on how to create wireless infrastructure and impart ICT education to students. In one instance where DG Postel, from the Indonesian Telecom Ministry, sent a letter asking a school to shut-down its network since it was illegally using the 2.4 GHz, the school approached the Ministry of Education that dispatched a letter asking DG Postel to unlicense the 2.4 GHz for education. The matter came to a rest at that point.

ISPs and other commercial users of Wi-Fi have not been as fortunate. Before 2005, 2.4 GHz was a licensed frequency and hence frequent raids were conducted by the police with direction from DG Postel on ISPs, corporates, community organizations that were using Wi-Fi[44]. In a raid, the police would typically seize and/or seal the equipment to prevent its use. However, best efforts to trace legal proceedings arising from the confiscation of Wi-Fi equipment drew a blank. From interviews with representatives from the Associations of Wireless ISPs and Cyber cafes, it became clear that bribing the police usually resulted in the return and unsealing of equipment, for the time being. This was probably one of the primary reasons why most confiscations never made it to the courts.

"Unlegal" activities[45] were not restricted to the use of the 2.4 GHz and 5 GHz bands for Wi-Fi. Because of high local and international backbone costs, it is sometimes cheaper for ISPs to connect to the Internet backbone directly via satellite, bypassing Indosat's international gateway and not having to pay for local leased lines. In most cases, direct access to a satellite link by ISPs is considered illegal since satellites do not have landing right in Indonesia. Representatives from APJII have argued that if bandwidth prices were to fall in Indonesia, the margin between the legal bandwidth price and the illegal one will be narrowed, and ISPs would have a greater incentive to avoid the grey market[46].

It is clear from the discussions with ISPs and large customers like schools, that cost factors were the primary reasons why Wi-Fi has been used as extensively in Indonesia. Although the licensing framework also played a part in this decision, it will be discussed in greater detail in the regulatory section and the next section will focus on unpacking the cost factors.

Leased Lines and International Bandwidth Prices

By any measure, the retail price of $4000 per month for a 512Kbps Internet link is very high. When the price for such a link is seen in proportion to the per capita income of Indonesia compared to any developed country, it is astronomical. By examining the cost components of the ISPs one would have a better understanding on why retail prices are so high. The two major variable cost components of a large ISP operating from Indonesia would be the cost of domestic leased lines and the international bandwidth. In order to determine whether leased line prices or international bandwidth prices are "high" in

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[44] Personal communication by Gunadi, DG Postel, August 18, 2005, Jakarta, Indonesia.

[45] In the interviews with ISPs when the author referred to some of their operations as being "illegal," the ISP representatives corrected my usage of that term by coming up with one of their own- "unlegal" to denote the grey area of the law and the widespread flouting of the rules governing Wi-Fi frequencies.

[46] *APJII - Internet Service Provider Production Cost to Drop*, 8 August 2003
Bisnis Indonesia.

Indonesia, it would be necessary to compare them with other countries in the region along with international benchmarks.

As can be seen in Table 3, a 2Mbps leased line for a 2km link provided by an operator costs $18,000 every year in Indonesia. Compared to another Asian country like India, Indonesian prices are 48 times that of India. Compared to the lowest EU benchmark price, Indonesian prices are four times as much. For the 200km link, the ratios highlighted in orange indicate that Indonesian prices are five to six times the price compared to EU benchmark and India.

When prices for international bandwidth are compared, Indonesian prices are also significantly higher. As can be seen in Table 4, the price of a 2Mbps full-circuit international link in Indonesia costs four to five times the price charged in India and the EU benchmark.

Table 3 : Annual Domestic Leased Line Prices

2Mbps Link	2km	200km
Indonesia	$18,000 Ratios India 1: 48 EU 1:4	$45,000 India 1:6 EU 1:5
India	$376	$7,603
EU Benchmark	$4,802	$9,219

Table 4 : Annual International Leased Line Prices

Full-circuit	INDOSAT	DT Putra	India	EU Benchmark
2 Mbps	$108,528 Ratios India 1:4 EU 1:3	$146,400 India 1:5 EU 1:4	$29,555	$36,868

Even when compared to its Asia Pacific peer countries, Indonesia's leased line prices are on the higher side as can be seen on Figure 6.

Figure 6: Annual Leased Line Prices for Asia Pacific Countries

Annual Leased Line Prices 2Mb, 2Kms

A bar chart titled "Annual Leased Line Prices 2Mb, 2Kms" with y-axis labeled "USD" ranging from 0 to 20000, showing the following values by country:

Country	Price (USD)
Taiwan	5,352.00
South Korea	8,520.00
Malaysia	13,116.00
Australia	16,320.00
Indonesia	18,000.00
Singapore	18,324.00
Hong Kong	18,756.00
India	376.00
EU	4,802.00
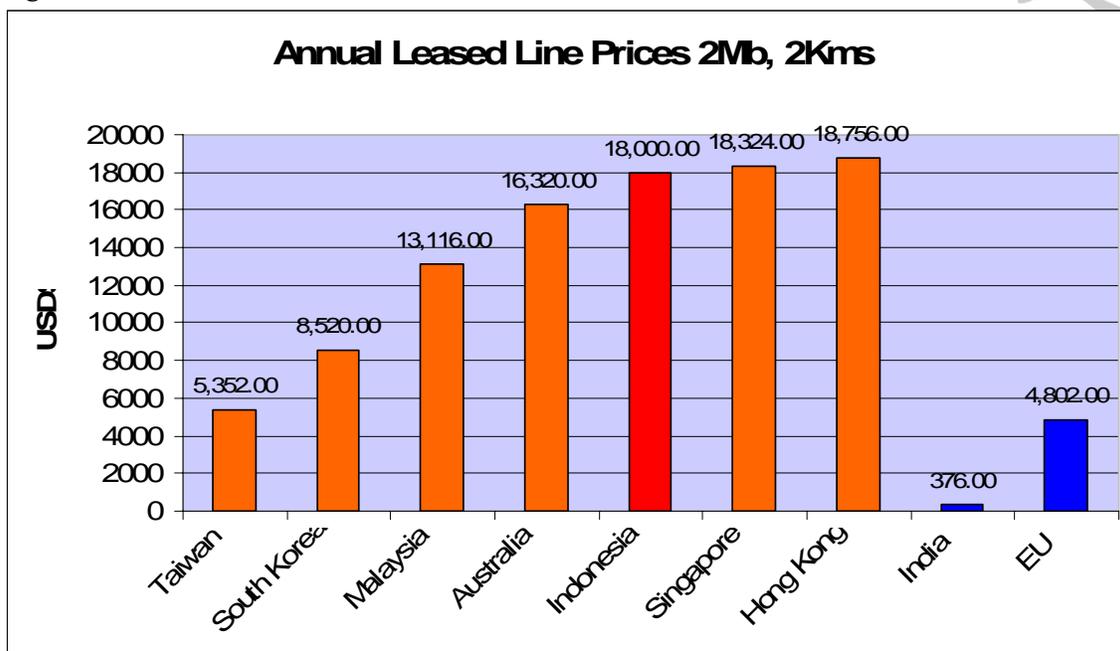
Source: Data from BRTI leased line study, EU 10th report, interview with Indonesian Network Service Provider

Since leased lines are a critical producer good for ISPs, (its importance will be discussed in greater detail in later sections) high leased line prices naturally results in high retail price for Internet services. As can be seen on both Figure 7 read in conjunction with the table and Table 5 comparing ADSL prices, retail price for Internet services are between four or five times more expensive in Indonesia compared to India.

Figure 7:

Comparison of Internet Prices (monthly) for Business Users in Indonesia & India

A bar chart titled "Comparison of Internet Prices (monthly) for Business Users in Indonesia & India" with y-axis labeled "USD" ranging from 0 to 4000 and x-axis labeled "Bandwidth", comparing Indonesia and India across bandwidths:

Bandwidth	Indonesia	India
64 kbps	~400	~150
128 kbps	~650	~250
256 kbps	~1200	~400
512 kbps	~2550	~600
1 mbps	~3750	~950

28

Bandwidth	Indonesia	India	Price Ratio
64 Kbps	$393	$128	3:1
128 Kbps	$639	$230	3:1
256 Kbps	$1180	$396	3:1
512 Kbps	$2596	$612	4:1
1 Mbps	$3776	$970	4:1

Table 5: Comparison of ADSL Retail Prices (monthly) in Indonesia & India

Bandwidth	Indonesia*	India**	Price Ratio
384 Kbps Usage limit: 1GB* 2GB**	$74	$23	3:1
512Kbps Usage limit: 2 GB*	$93	$41	2:1

Innovation Around Constraints

The Indonesian case, as it has been presented, is an exemplar of innovation around constraints. The inadequate supply of network infrastructure, both of backbone and leased lines, resulted in Wi-Fi being chosen as a substitute for filling the "missing link" in the network. The high price of last mile infrastructure, i.e., domestic leased lines prices, meant that ISPs and others relied on a more cost-effective solution in the form of Wi-Fi links. High price of international bandwidth saw ISPs connecting directly to satellites for their link to the Internet backbone. The high retail price of Internet service spawned a large number of unlicensed reseller-ISPs using Wi-Fi to recoup the high price.

The question of why Indonesia has more Wi-Fi deployed than most developing countries has been partially answered. Initially, ISPs were not given the build or buy options because the incumbent did not provide leased lines and backbones. It is possible that Telkom did this to prevent potential competition from ISPs in the Internet service market and in the voice market with the possible use of VoIP by ISPs. But it is also possible and likely, as will be explored in greater detail below, that Telkom did not have adequate infrastructure on the ground to provide leased lines or backbones to ISPs, even if they wanted to. From the ISPs' point of view, whether Telkom did or did not have adequate infrastructure, the result still meant that they (ISPs) did not have access to infrastructure that they needed and were forced to improvise with available technology for a work-around solution. If ISPs were allowed to invest in communication

infrastructure it is likely that they would have been locked into a different technology. But in this instance, having invested in Wi-Fi and finding the results acceptable, many ISPs continued to use it even when Telkom made leased lines available.

Many countries in the world share Indonesia's problem with high lease line and international bandwidth prices[47]. However, we do not see many countries like Indonesia where Wi-Fi has been so extensively deployed. Hence, the allusion above that this question has only been partially answered. There are other factors that have contributed to the unique case of Indonesia, namely the role played by civility society and the licensing framework governing the telecom sector. They will be explored later.

The anomaly between empirical evidence suggesting extensive Wi-Fi deployment but low Internet subscriber base in Indonesia can be explained by the high cost of Internet service and the multi-tier retailing of Internet service by unlicensed ISPs. APJII, the Internet Association, gets its subscriber data from the registered ISPs who are licensed. Considering, that at least a third of the ISPs in Indonesia are not registered and reselling of Internet service is widespread, it would be reasonable to assume that a large number of subscribers and users on unlicensed networks are not being counted[48]. And in fact, Indonesia may have more Internet users than it is being given credit for. The actual Internet user numbers can be addressed by conducting a random sampling of the population.

Finally, the significantly high price for basic communication infrastructure that is critical for Indonesia's transition into a developed economy, indicate a failure of the market and the regulatory structure that has allowed such high prices. The next sections will explore the regulatory and market environment to explain not only why communication infrastructure prices were high but also the behaviour of the incumbent and the competitive ISPs.

Indonesia's Telecom Reforms

Backdrop

The performance of the Indonesian telecom sector has been uneven. Although, mobile growth rates are impressive, the rest of the sector is plodding along. In 2005, Indonesia has a combined mobile and fixed line teledensity of 19.2 per 100 inhabitants [4.4 fixed, 14.8 mobile]. Compared to other members of the Association of South East Asian

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[47] In fact, India that compares very favourably with Indonesia on both domestic and international leased line prices, shared Indonesia's problem before the telecom sector was reformed.

[48] Although APJII also provides a separate figure for Internet users for Indonesia, that ITU also reports in its indicator database, the author found that APJII routinely multiplies the subscriber base by 10 to obtain the Internet user. Hence the user numbers are not an accurate indicator of actual Internet users in Indonesia.

Nations (ASEAN), Indonesia lags behind[49]. For example, in Malaysia, the teledensity rate for fixed and mobile combined is 76.61 percent and in Philippines it is 44 percent during the same period[50]. The digital divide is acute not only between Indonesia and its peer countries but within Indonesia itself. In the Eastern Indonesia provinces, only 0.02 percent of the population has fixed-line phones. More than half Indonesia's 70,000 villages (or about 43,000 villages) don't have access to any public telephones.[51]

The Asian financial crisis of 1997, resulted in a dramatic decline in Indonesia's economy that led to social and political unrest. Because of the financial instability caused by the sharply depreciating Ruppiah among other factors, the Indonesian government was forced to approach the IMF for a loan of $10.4 billion[52].

The economic crisis of 1997 also had a profound impact on the telecom sector. Although foreign and domestic investments dried up in the aftermath of the political turmoil unleashed by the financial crisis and forced the Indonesian government to bring the ambitious Nusantara 21 Project to connect Indonesia's major islands by submarine and terrestrial cable to a halt[53], the long term gains from the restructuring of the sector due to this external shock are being reaped today. As can be seen from Figure 8, the telecom sector as a whole is more dynamic than it ever has been.

The crisis forced the Indonesian government to follow a reform trajectory that it probably would not have taken if left to itself. IMF's letter of Intent issued in January of 2000[54], stipulates a host of reforms for the telecom sector including making the sector fully competitive by first privatizing both state-owned telecom companies (Telkom & Indosat) and restructuring the sector; finalising and implementing regulations for the 1999 Telecommunications Law that explicitly separates policy and regulatory functions; rationalizing the extensive cross-ownership of Telkom and Indosat in the sector, among other measures.

After more than five years since the IMF commitments, the continued dominance of the two government-run fixed-line operators and lack of an independent regulator are clear testimony of the Indonesian government's reluctance to embrace the reform process. As can be seen from Figure 3 and discussed in the next section in greater detail, the Indonesian government has largely made nominal reforms, more true to the letter than the spirit of its agreement with the IMF. Despite the halting steps, the reform process has

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[49] "Still long way to go to bridge digital divide," 17 May 2002, *Jakarta Post.*

[50] *The ITU Internet Report: The Internet of Things*, 2005, ITU, Geneva.

[51] "Indonesia requires digital connectivity," by Craig Warren Smith and Idris F Sulaiman, 30 September 2004, *The Jakarta Post.*

[52] Indonesia Letter of Intent with the IMF, available at: http://www.imf.org/external/np/loi/103197.htm
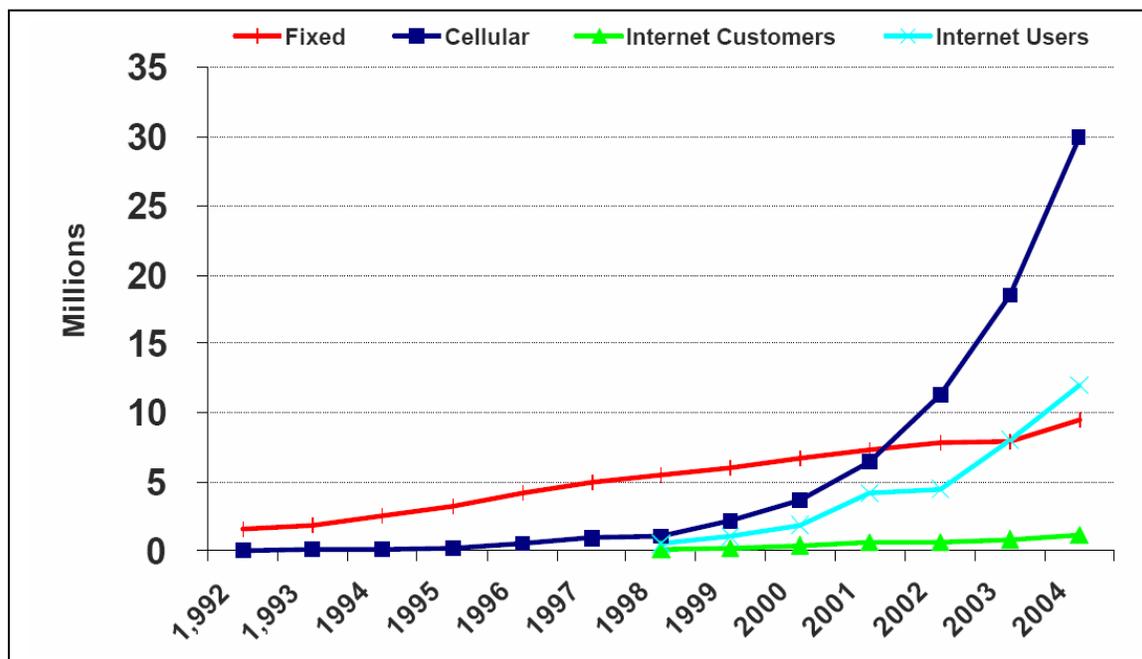
[53] ".id: Indonesia country profile," M. Chowdhury and H. Murniadi, available at: http://www.cid.harvard.edu/cr/profiles/Indonesia.pdf

[54] http://www.imf.org/external/NP/LOI/2000/idn/02/index.htm

yielded a vibrant mobile sector that is competitive and has witnessed some impressive growth.

Figure 8: Growth of Mobile, Fixed and Internet

Overview of the Indonesian Sector Reform Process

Indonesia's telecom reform process can be broadly divided into two stages, the first one spanning the early 1990s with the partial privatization of the state-owned telecom incumbents and the second one post the 1997 financial crisis with the setting up of a regulatory agency and ending of the exclusivity rights of the incumbents in fixed telephony[55]. As can be seen from Figure 9, the reform process in Indonesia has been slow and halting with the result that even after 15 years since the process was initiated, the Indonesian telecom sector is still dominated by two government-controlled incumbents and saddled by a weak regulatory body. The obvious success story is in the competitive mobile telephony sector which has shown remarkable growth rates and has contributed overwhelmingly towards the total teledensity (14.8% mobile versus 4.4% for fixed[56]).

The first generation of reform consisted of liberalization of the sector that allowed private investment in the sector in 1980, the granting of competitive licenses for the

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[55] Indonesia: Telecommunications on a road to reforms, K. Sugondo and R. Bhinekawati, in *Telecommunications Reform in the Asia-Pacific Region* (Eds.) Brown et al., Edward Elgar, Northhampton, MA, USA, 2004.

[56] BRTI & Indonesian Telecom Industry Overview, Koesmarihati, June 2005.

provision of GSM service, Internet services and the partial privatization of the two government-owned operators[57].

Under the telecom legislation of 1989, Telkom and Indosat were designated as the "organizing bodies" for provision of telecom service and private entities could co-operate with them to provide infrastructure and services. Under the Pola Bagi Hasil (PBH) project from 1990, private companies installed and operated fixed lines services on behalf of the two telecom operators and followed a revenue sharing model. Most of the revenue sharing agreements were later transformed into joint ventures[58]. These joint ventures were termed KSOs. Although PT Telkom was the exclusive provider of fixed line local, long distance and leased-line services during the first stage of reforms, it granted in 1995 15 year "KSO" concessions to private consortia to operate fixed line services on a monopoly basis in five of seven regional districts. PT Telkom retained control of the two most profitable regions, Greater Jakarta and East Java. The concessions attracted substantial foreign investment from large international operators including France Telecom, Media One, Telstra, NTT, Cable & Wireless and Singapore Telecom[59]. However, the financial crisis of 1997 rendered most of the KSOs bankrupt.[60] That and disputes with the private consortia led Telkom buying back four of the five KSOs by 2004.

The government created Satelindo in 1993 to be the second provider of international service. However, competition was limited since Indosat owned 7.5 per cent of its shares and Telkom 25 per cent[61]. Furthermore, Satelindo and Indosat were required to charge the identical tariffs for international service. Satelindo was also granted a GSM license in 1994. Although it still continues to provide GSM service, Satelindo's international operations have been merged with Indosat.

Currently the market structure, as seen on Table 6, show why the barriers to market participation are high. Exclusive licenses make Telkom the monopoly provider of fixed line services. Even though the government has recently allowed Indosat to provide fixed services, Indosat does not have adequate infrastructure on the ground to compete with Telkom and provide fixed services like leased lines. In fact, Indosat relies on Telkom for leasing lines and domestic backbone links.

Table 6: Barriers to Market Participation

Telecom services	Telecom operators
Fixed wireline local	Exclusive right 1996-2010 PT Telkom

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[57] "Telecommunications in Indonesia and its WTO commitments," DG Telecom & UNESCAP, 2003.
[58] Indonesia Telecoms Market Intelligence Report, August 2005. Available at: www.espicom.com
[59] *Ibid.*
[60] *Kretek Internet: Indonesia Case Study*, ITU, Geneva, 2002.
[61] *Ibid.*

Fixed domestic LD	Exclusive right 1996-2005 PT Telkom
Fixed wireless local	Limited competition (Satelindo)
Fixed international	Monopoly 1995-2004 (Indosat)
Mobile GSM	Competitive (Satelindo, Excelkomindo, Telkomsel etc.)
Internet Service Provision	(Quasi?) Competitive Currently 124 ISPs official, 54 unlicensed

The impetus for the second generation of reform came primarily from the IMF as was outlined earlier. As part of the bailout package to the Indonesian government, IMF's letter of intent stipulated among other things, rapid privatisation of both state-owned telecom companies, finalising regulations for a new Telecommunications law and the setting up of a transparent and predictable regulatory body[62]. The Indonesian government complied with some of the stipulations by passing the Telecommunications Law No. 36/1999, however compliance was mostly in letter rather than spirit.

The new law prematurely terminated the exclusivity right for PT Telkom on fixed local call (from Dec 2010 to August 2002), long distance (from Dec 2005 to August 2003) and PT Indosat's exclusivity right for international calling (from Dec 2004 to August 2003[63]). The Indonesian government's idea of competition was to allow the two incumbents, PT Telkom and PT Indosat, to provide fixed telephony services for local, long distance and international. However, to date, no new licenses have been given to any operators for fixed line services. The government has however doled out US$49 million[64] as the first instalment of "compensation" to PT Telkom for theoretically ending its monopoly early. The government has not undertaken additional divestment of the telecom incumbents and remains in control of both companies. The government owns 51% of share in PT Telkom and the "golden" and controlling share of Indosat.

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[62] Telecommunications Sector, British Embassy in Indonesia, URL: www.britain-in-indonesia.or.id/commer11.htm

[63] The role of a sectoral regulator: Case of Indonesia in telecommunication sector, Bambam Adiwiyoto, KPPU, at the APEC seminar on Best Practices in the Enforcement of Competition Policy, Pucon, Chile, 26 May 2004.

[64] Telkom gets first payment from government, *Jakarta Post*, January 14, 2006.

Overview of the Indonesian Regulatory Reform Process

Unlike most countries in the world, Indonesia is endowed with two regulatory bodies but this hasn't translated into an effective regulatory environment. Although the Telecommunication Law of 1999 provided the government the option to create an independent regulatory agency, that option was not exercised until 2003. A ministerial decree in 2003[65] established the Indonesian Telecommunications Regulatory Body (BRTI)[66] to be effective starting January 2004. However, since its inception, BRTI was seen as a "transitional" body that would become fully independent only at some undetermined time[67].

In the interim, BRTI is crippled since legal powers have not been transitioned to the body and it lacks any enforcement powers. Currently, the Regulatory body's budget is allocated from the Ministry (DGPT). As can be seen from Figure 10, BRTI only plays an advisory role to the DGPT and the Ministry and DGPT has the final word on any decision. Although, DGPT is required to consult BRTI on regulatory matters, the former is not obligated to follow its recommendations.

The Regulatory Committee of the BRTI is composed of five members namely the Chairman, who is the Director General of Postel (DGPT), and four members who are selected by an independent panel representating experts from the telecom and IT field, legal field, from economics and from civil society. Since the Chairman is also the DG at the telecom Ministry, the separation of policy and regulatory functions have not been maintained. Any semblance of independent regulation is compromised by the above arrangement.
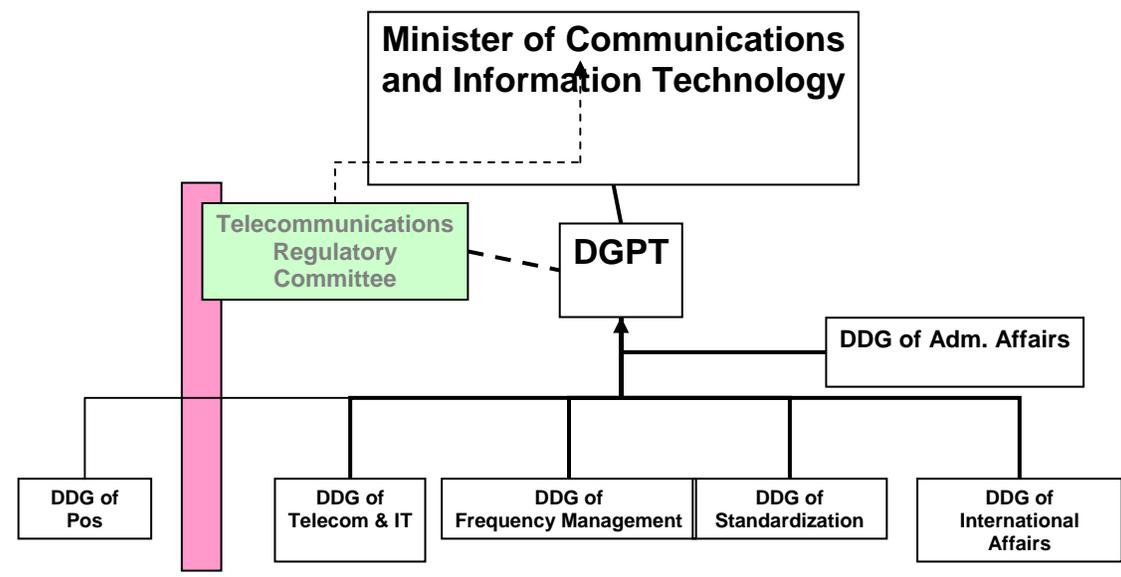
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[65] Ministerial Decree No. 31 of 2003.

[66] Badan Regulasi Telekomunikasi Indonesia (BRTI)

[67] Based on interview with Koesmarihati, Committee Member, BRTI on August 24, 2005.

Figure 10: Indonesian Telecommunications Regulatory Structure

Notes :
- BRTI (Indonesian Telecommunications Regulatory Body)
- Line of Command
- Line of Coordination
- Report to

Source:" Indonesian Telecommunications Regulatory Body," BRTI, PPT presentation, August 2004.

The telecom licensing structure has played a crucial role in the adoption of Wi-Fi by ISPs as a substitute for backbone. Currently, the telecom licensing structures is divided into three categories[68]:

1. Telecommunications Network Providers;
2. Telecommunications Services Providers;
3. Telecommunications for special purpose[69].

The telecommunications Network Providers are the only ones who are allowed to build telecommunication infrastructure in Indonesia. With a Network Provider license, it is possible to provide services for
- Fixed Network : local , long distance , international and close user network
- Mobile Network : Terrestrials , Cellular and Satellite

Since ISPs are considered to be telecom Service Providers they are not allowed to deploy any infrastructure. The current licensing framework is one of the contributory factors to

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[68] "Indonesian Telecommunication Licensing," BRTI, PPT presentation, October 2004.
[69] The third category of license is for government, defense communication and broadcasting.
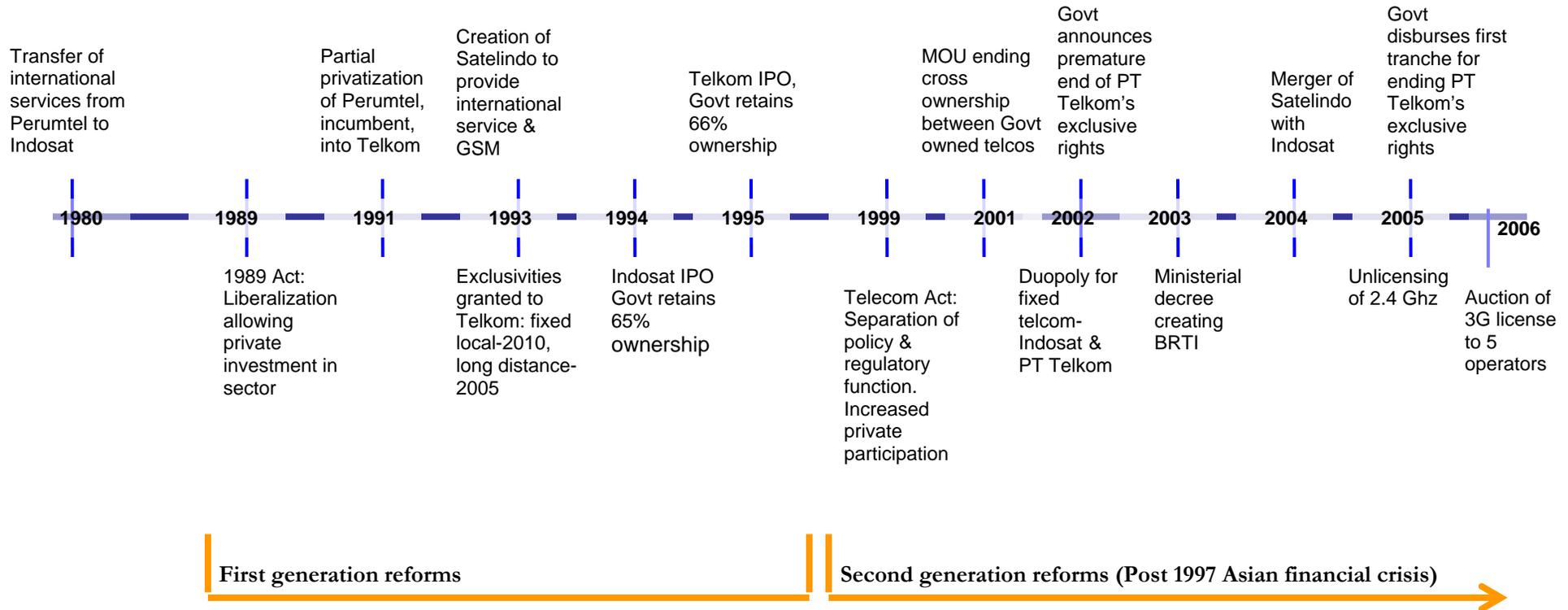
the inadequate supply of telecommunication infrastructure in Indonesia and a barrier to Internet growth. The single-supplier situation in the fixed line services and the licensing framework, were the primary reasons identified by representatives from the Indonesian Infocom Society, MASTEL for the scarcity of network infrastructure which was constraining Internet development[70]. According to Setiyadi, there are not enough Network Operator Centers (NOCs) that interface between the last-mile and the upstream backbone providers in Indonesia. Furthermore, since the ISPs are not allowed to build network infrastructure because of the licensing conditions, it weakens the ISPs' negotiating power with higher tier ISPs. MASTEL representative strongly recommended that the Indonesian regulator should allow ISPs to build their own infrastructure so that they do not need to rely on the monopoly network provider.

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[70] Personal communication from MASTEL representatives Setiyadi, Juni Soehardi etc. August 19, 2005, Jakarta, Indonesia.

Figure 9: Timeline of Indonesia's Halting Reform Process

Transfer of international services from Perumtel to Indosat

Partial privatization of Perumtel, incumbent, into Telkom

Creation of Satelindo to provide international service & GSM

Telkom IPO, Govt retains 66% ownership

MOU ending cross ownership between Govt owned telcos

Govt announces premature end of PT Telkom's exclusive rights

Merger of Satelindo with Indosat

Govt disburses first tranche for ending PT Telkom's exclusive rights

1980   1989   1991   1993   1994   1995   1999   2001   2002   2003   2004   2005   **2006**

1989 Act: Liberalization allowing private investment in sector

Exclusivities granted to Telkom: fixed local-2010, long distance-2005

Indosat IPO Govt retains 65% ownership

Telecom Act: Separation of policy & regulatory function. Increased private participation

Duopoly for fixed telcom-Indosat & PT Telkom

Ministerial decree creating BRTI

Unlicensing of 2.4 Ghz

Auction of 3G license to 5 operators

First generation reforms

**Second generation reforms (Post 1997 Asian financial crisis)**

Uneven backbone availability

The backbone network is an important architectural element for building networks that can span across one or more countries. A backbone can tie together diverse networks in the same city, or networks in different cities, or regional and national networks to each other. It provides a path for the exchange of information between different sub-networks that are connected to it. Generally, the backbone's capacity is greater than the networks connected to it. Without backbones, local networks are isolated and are able to exchange traffic only with networks in their immediate vicinity. Since backbones are the basic building blocks of any national telecommunication infrastructure, their absence in a region effectively disconnects the people from that area from the rest of the world even if local networks are in existence.

In the early years of the Internet in Indonesia, Wi-Fi played a significant role as a low-cost, low-bandwidth backhaul for ISPs. On many routes, even if the incumbent was willing to provide leased lines to ISPs, it was not able to because it lacked backbone infrastructure in many of the islands and regions. Outside of Java and Sumatra wired backbone infrastructure was non-existent. Even today, Papua, Moluccas, Kalimantan and Sulawesi have poor backbone coverage and have to depend on expensive satellite service for backbone. As can be seen in Figure 11, showing the backbone map for Indonesia based on available information, fiber optic based backbone is sparsely deployed in Indonesia. And much of this infrastructure is of recent origin and has been deployed in the last five years.

Figure 11: Backbone Map of Indonesia
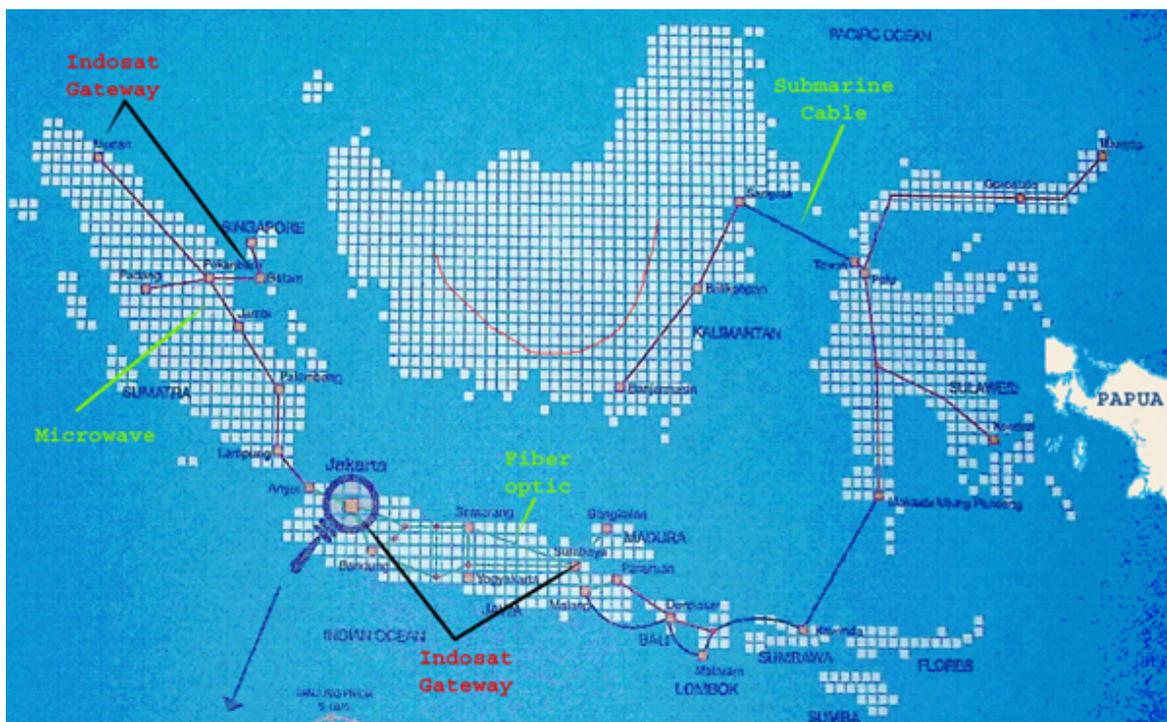
The backbone in Sumatra consists of a terrestrial microwave network which is linked to Java through the Bali islands with a sub-marine cable. Among all the islands, Java is the one where the greatest amount of fiber is deployed in the backbone network. Most of the other islands rely on microwave links or satellite for backbone connectivity.

Currently, the backbone networks constructed by some of the operators are as follows[71]:
➢ PT. Indosat has built fiber optic sub marine cable for its international services gateways in Jakarta, Medan, Surabaya, and Batam.
➢ PT. Excelcomindo has built 1085 km length of fiber optic sub marine cable from Nusa Tenggara through Sulawesi and Kalimantan.
➢ PT. Excelcomindo has built both fiber optic and microwave for its own backbones and consist of:

Fiber optic backbone:
• Anyer – Jakarta – Surabaya with 4 rings of 2600 km length;

Microwave backbones consist of:
• Java : Java – Bali – Nusa Tenggara;
• Sumatera: Jakarta – Lampung – Pekanbaru – Batam – Medan;
• Kalimantan: Banjarmasin – Balikpapan – Samarinda
• Sulawesi: Makassar – Palu – Manado.

Excelcom's backbone network spanning approximately 4,400 kilometers was completed only in September 30, 2003. It consists of several fiber optic cables that have been installed alongside the railroad tracks from Java Barat to Surabaya, and connects all major cities and towns in the Java Island[72]. Excelcom uses VSAT (Very Small Aperture Terminal) to connect to the backbone in remote areas where wired backbone infrastructure is missing. The ease of setting up a VSAT link compared to laying terrestrial cable along with the low costs involved make it a viable solution for providing cellular service to areas that would otherwise remain unconnected.

However, the building of the above backbone links in recent years still does not adequately address the lack of backbone infrastructure in Indonesia. This can be surmised from the fact that the government and the operators have large-scale and long-term fiber optic deployment plans for the country.

In June of 2005, PT Telkom signed a turnkey contract with Siemens and NEC to jointly develop an optical fiber cable system that will connect 30 cities on the Indonesian islands of Java, Sumatra and Kalimantan. The new optical fibre network called *JASUKA Backbone Ring* consists of 1,040 km of submarine and 780 km of terrestrial telecommunications transmission systems which will be in place in mid-2006. It will be

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[71] *Indonesian Data*, Directorate General of Posts and Telecommunications, August 2005.

[72] Online: http://www.xl.co.id/Jaringan_dan_Infrastruktur/

configured as two rings and will utilize submarine and terrestrial optical networking. The system will have an initial capacity of 20 Gbit/s for submarine and 10 Gbit/s for the terrestrial portion and can be upgraded up to 320 Gbit/s[73].

Excelcom is in the process of building subsea links that will connect Senggigi Lombok with Sumbawa, and Palu, Sulawesi with Sangata, Kalimantan. Once completed, the undersea cable with a capacity of 2.5 Gbit/s will connect the islands of Kalimantan and Sulawesi directly to the fiber optic backbone in Java.

The Indonesian government has a much more ambitious though long term plan of building a nationwide, high capacity backbone network. The *Palapa Ring* project will create 30,000 kilometers fiber-optic backbone rings that will connect all the major islands. This project is estimated to cost US$1.6 billion and is targeted to be finished only by 2020. Tentatively, the construction of the Eastern ring, comprising of Papua, Maluku, and East Nusa Tenggara, is supposed to start in 2008 and finish in 2012. The Middle ring, comprising Sulawesi, Indonesian Borneo and West Nusa Tenggara is due to be built between 2013 and 2016 while the existing network covering Java and Sumatra would be refurbished in the period of 2017 to 2020[74]. However, this project is still in the planning stages and the government has yet to draw up a road map or how it will attract more than $1 billion in capital it expects to come from the private sector.

For Indonesia's total area (water and land) that is nearly 2 million square kilometers[75], the incumbent has laid only 9,555 kilometers of fiber optic cable to connect the main islands in the country[76]. Indonesia's per square kilometer coverage of fiber based backbone is much lower compared to a country like India that is also large and has difficult terrain to connect. Compared to the India, Indonesia's backbone density per square kilometers is nearly 28 times less, as can be seen on Table 7.

Table 7: Backbone Density Index

	PT Telkom Indonesia	BSNL India
Total Fiber Optic Network	9,555	462,527
Total Area [land & water] sq. kms	1,919,440	3,287,590
Backbone Density Index (BDI)	**0.005**	**0.14**

[73] Siemens and NEC to jointly supply nationwide telecommunications system for Indonesia, NEC News, June 27 2005

[74] Huge telecom project offered at Summit, *Jakarta Post*, Monday, January 17, 2005.

[75] CIA Factbook, online: http://www.cia.gov/cia/publications/factbook/geos/id.html

[76] Telkom launches fiber optics communication system, *Jakarta Post*, September 27, 2005.

Indonesian incumbent has 28x LESS fiber optic backbone per square kilometers than Indian incumbent

The inadequate supply of backbone network in Indonesia is primarily due to the lack of competition in the telecommunication infrastructure sector. Before Excelcom, the mobile provider, built much of the recent backbone networks to connect their base stations, Indonesia was served by the existing backbone networks of the incumbents. PT Telkom and Indosat had monopoly over domestic and international wired infrastructure, respectively in the country. As is well documented in the literature of economics, monopolists do not invest the full amounts required for economic efficiency when they are provided with monopoly returns on their investments. This is also the case in Indonesia where we have seen backbone infrastructure being scarce outside the islands of Java and Sumatra and unevenly deployed even in those two islands. It was not as if there was no demand for backbone infrastructure from ISPs, business users and other telecom operators. The extensive deployment of Wi-Fi in the early years of the Internet for backhaul functions is a testimony to that. The inadequate supply of backbone and lease line infrastructure has forced ISPs to use Wi-Fi as a poor substitute to haul data over long distances.

The first time that Wi-Fi was used as a backhaul connection to serve the function of a low-capacity backbone was in 1996 by the ISP Cabi.net[77]. During the period of 1996-98, PT Telkom did not have adequate infrastructure and the availability of leased lines was scarce even if the incumbent agreed to rent. There were no providers for 2mb tail for the local link and the best that PT Telkom could provide was 64 kbps[78]. Wi-Fi became a viable solution for ISPs because Wi-Fi access points could be set-up easily in areas that lacked network infrastructure, it offered a higher bandwidth than was available and at a much lower price. At that time, the use of 2.4 GHz bands for Wi-Fi was illegal but this did not prevent ISPs from using the frequencies. Hence, in an uncompetitive telecom infrastructure market, where supply of backbone and leased line infrastructure was constrained, Wi-Fi was able to circumvent the supply constraint by providing ISPs an alternative infrastructure solution. In regions of Indonesia without backbone infrastructure, Wi-Fi filled the "missing link."

However, using Wi-Fi as a substitute for backbone is a sub-optimal solution. Wi-Fi is prone to interference and does not provide carrier-class reliability of an actual backbone link. Furthermore, the width of a Wi-Fi transmission pipe is of a different magnitude compared to fiber optic or even microwave links and the throughput rapidly degrades with distance. The most important disadvantage of Wi-Fi is its severely limited range (10-20kms) compared to fiber optic cables that can be strung around the globe. Hence,

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[77] Personal communication, John Simanjuntak, Vice Secretary General, APJII, Jakarta, August 19, 2005.

[78] Personal communication, Teddy Purwadi, Secretary General, APJII, Jakarta, August 19, 2005.

not surprisingly, Indonesian ISPs who were interviewed were unanimous about their preference for genuine backbone and leased line links if they were available and the prices were cost-oriented[79].

Currently, the use of Wi-Fi as a backhaul network is on the decline in the larger cities where adequate backbone infrastructure is more readily available. Despite this, some ISPs continue to use Wi-Fi in the 5.8GHz bands to haul data over large distances that can be as far away as 14 kms in some cases. ISPs that continue to use Wi-Fi in large cities do so to primarily avoid paying for lease lines that are priced significantly higher than benchmark prices in other countries, as was shown earlier. Figure X is an example of an ISP in Jakarta using 5.8GHz to connect its business customers to its hub. Some of the links are over 12 kms long.

Figure X: Wi-Fi as Backhaul and Access Links in Jakarta

The Importance of Leased Lines

Leased lines are usually rented from a telecom operator by a private party to provide dedicated high-bandwidth connectivity between two or more locations. This link can be used by the private party for providing data, voice or Internet service to its subsidiaries or to retail customers. Hence, leased lines are crucial inputs for providing a host of communication services required by the information based economy, globally. Businesses factor in the price and availability of leased lines for making investment

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[79] Personal communication, representatives from INDOWLI (Indonesian Wireless Internet Community), AWARI (Association of Cyber Cafes) and APKOMINDO (Association of Computer Businesses), Jakarta, August 18, 2005.

decisions on where to select locations for factories, call centres and Business Process Outsourcing[80]. Leased lines are especially important to small Internet Service Providers (ISPs) that do not own their own regional networks or last-mile access to their end-users, as is the case with most Indonesian ISPs. ISPs usually rent connectivity from a telecom operator to connect their retail customers to the Internet. Effective competition in the leased line market is crucial for cost-based and non-discriminatory access to this vital infrastructure by ISPs.

However, regulation of leased lines have not only been ineffective in Indonesia but also in many countries where the incumbent telecommunications operators continue to dominate over local access leased lines. By discriminating among customers on pricing and provisioning of leased lines, the incumbent abuse their dominance over this bottle-neck facility. It is therefore essential for regulators to ensure that incumbent operators are obliged to provide tail-circuits on a non-discriminatory basis to allow new ISPs and operators to establish themselves and the time to build their own infrastructure.

Many developing countries have no effective competition in leased line markets resulting high price, poor quality and uncertain availability. One of the most effective ways of ensuring more widespread diffusion of Internet access, is to have effective competition in this market. As a number of studies have shown, low leased line prices lead to higher Internet growth rates[81].

Community Participation in Network Rollout

As mentioned previously, many countries in the world share Indonesia's problem with high leased line and international bandwidth prices[82]. However, we do not see many countries like Indonesia where Wi-Fi has been so extensively deployed. There are other factors that have contributed to the unique case of Indonesia, and the role played by civil society is an important one.

To bridge the significant digital divide in Indonesia, community level action have been undertaken by the School Information Network and other "geek" activists. In their view, to bridge the digital divide, it is not only necessary to supply infrastructure but also to develop human resources. The demand for information infrastructure as well as ability to exploit the infrastructure will only happen in a society that has invested in developing human resources by providing ICT education. Failure to increase the society's level of education will likely to impede the development of information infrastructure within the society.

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[80] INTUG submission to the ITU-T Study Group 3, November 2003. Online: http://www.intug.net/submissions/ITU-T-SG3_leased_lines.html

[81] "Promoting Internet development: the case of Argentina," B. Petrazzini & A. Guerrero, *Telecom Policy* 24, 2000.

[82] In fact, India that compares very favourably with Indonesia on both domestic and international leased line prices, shared Indonesia's problem before the telecom sector was reformed.

Civil society groups recognized that the ability to distribute the needed knowledge and skills at low cost would be crucial in creating demand and producing needed skilled technicians to deploy the infrastructure. With this in mind, seminars and workshops have been conducted by ICT practitioners and "geek" activists. More than 200 ICT technicians, teachers and knowledge producers are trained every year in road-shows and workshops held across Indonesia. Developing ICT human resources in Indonesia in this manner has been ongoing for more than a decade.

This civil society action has created a pool of trained individuals who have enabled the deployment of Wi-Fi and Internet connectivity in their communities. Entrepreneurs have tapped geek activists' know-how on building antennas to setting up and managing wireless networks. Because of the low-cost of Wi-Fi technology, a fair number of small-sized ISP entrepreneurs have also arisen from this pool of ICT activists.

Civil society groups lobbied with the Indonesian government to delicense the 2.4 GHz frequencies and their efforts were an important factor in the government according legal status to the use of Wi-Fi that was already widespread. In January 2005, the 2.4GHz was unlicensed. Currently, civil society groups are lobbying for unlicensing of the 5 GHz bands.

Conclusions

Wi-Fi "innovations" in Indonesia are not a result of enlightened policy designed to extend communication infrastructure to unserved areas but rather a workaround solution to hostile market and regulatory conditions. As a study on leveraging wireless for achieving rural connectivity notes, institutions matter[83]. Unless effective policies are in place that allow market entry, manage rights of way and promote cost-oriented and non-discriminatory access to bottle-neck facilities, efforts at bridging the digital divide using wireless technology will fall short of its objectives[84]. This has been the experience in Indonesia and is a lesson for other developing countries too. Until credible regulatory reforms are carried out that empowers BRTI, the regulator and liberalizes the telecom market further, the gains in the telecom sector generally and Internet specifically will be limited and unsustainable in Indonesia.

The silver lining for Indonesia is the inherently lower costs of Wi-Fi compared to wired last-mile access technologies, providing the country with potentially explosive Internet growth if conducive regulatory and market conditions are created that lower prices and allow greater participation. An increasing pool of effectively trained, ICT-savvy teachers

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[83] "Wireless communication and development in the Asia-Pacific: Institutions matter," R. Samarajiva, *In Press*.

[84] *Ibid.*

and "geek" activists make it more likely that the benefits of connectivity and infrastructure can be leveraged most optimally in Indonesia.

There are a number of lessons from Indonesia that may be applicable to developing countries:

1. The foremost among them is that although technology and innovations that its spawns have certain transformative qualities, they cannot by themselves bridge the digital divide. It is crucial to carry out the hard work that regulatory reforms entail in order to reap the full-benefits of technology.
2. Indonesia is a clear example that Wi-Fi deployment can be commercially viable and can be sustained with private investment.
3. Countries with the most obdurate governments can take heart from the fact that civil society can play an important role in influencing government to delicense Wi-Fi frequencies and preparing the ground for infrastructure development through training.
4. Developing countries with entrenched telecom monopolies can hasten the deployment of broadband Internet by delicensing Wi-Fi frequencies. If ISPs can use Wi-Fi in the access network they can bypass incumbent's local loop.

Policy recommendations

In order to address the problem of not enough supply of network infrastructure, the government could invest in creating more backbone by laying submarine and terrestrial cable and creating a fiber ring connecting the main islands, as it has proposed to do under the *Palapa Ring Project*. However, based on the timetable the government has proposed, the infrastructure will not be created any time in the near future.

Furthermore, the current economic outlook for the Indonesian government due to high crude oil prices and subsidy payouts, does not inspire much confidence in its ability to mobilize the necessary capital for rolling out backbone infrastructure. An easier option for the government would be to change its licensing framework to allow more players to invest in Indonesia's communication infrastructure.

The swiftest remedy for high leased line prices is for BRTI to step in and compel Telkom to lower its prices. In the medium term, the regulator could develop an access regime for leased lines that would provide guidelines to fixed line operators on price, delivery schedule and quality of service. For the long term, the government can open up the fixed line market, as it has done for the mobile market, and allow competitive forces to take root and determine prices.

For high international bandwidth prices, the Indonesian government can issue price ceilings, like the Indian regulator did for IPCLs that brought down the incumbent's

prices by as much as 70 per cent. By legalizing landing rights of foreign satellites and allowing ISPs to connect directly to the Internet backbone, the government could create enough competitive pressure on Indosat that may lead to lower international prices. For the long term, the government can end Indosat's monopoly by allowing more players in the international gateway market.

If even some of these steps are undertaken by the Indonesian government, the problem of high Internet retail prices will take care of itself.