THE ROAD TO BROADBAND DEVELOPMENT IN DEVELOPING COUNTRIES IS THROUGH COMPETITION DRIVEN BY WIRELESS AND VOIP

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Paper prepared for the workshop:
Wireless Communication and Development: A Global Perspective
Annenberg Research Network on International Communication
October 7-8, 2005
(http://arnic.info/workshop05.php)

The author gratefully acknowledges valuable comments from Carlos Sánchez (OSIPTEL, Peru), Marcel Silva (Subtel, Chile), Ermanno Pietrosemoli (U. de los Andes, Venezuela), Juan Belt (USAID), David W. Mendoza (USAID), Bernard J. Mazer (USAID), Chat Garcia Ramilo (APC), Bona Simanjuntak (Center for ICT Studies, Indonesia), and Rose Maria Bonello (Telecom Italia).

The views expressed in this document are those of the author and not necessarily reflect the official position of the FAO.

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Introduction

Internet telephony (VoIP) and Wireless technologies are radically transforming the telecommunications sector. By enabling rapid low cost deployment of service to traditionally underserved populations and expanding backhaul and last mile connectivity options, wireless technologies are making it easier for new competitors to arise and begin to challenge the traditional dominance of circuit switch operators. On its own, VoIP enhances the value of IP Networks and challenges traditional revenue models of incumbents. The two combined, wireless and VoIP, have the potential to wreak havoc with businesses dependent on land lines.

These technological advances are seen in developed countries as opportunities to further facilities-based competition and are welcomed by independent regulators. Incumbent operators, whose dominance is challenged, observe these developments guardedly, with the most enlightened adjusting their market offers to profit from the new technologies. Competition in these countries takes place predominantly in profitable dense urban markets that can sustain several competing infrastructural networks – mobile, cable, land lines.

The situation is different in developing countries. Regulators are generally weak, lacking independence and at times part of a system in which the legacy operator captures the regulatory and political processes. Monopoly operators serving metropolitan markets have faced some challenges mainly from mobile networks. The markets that remain untapped are rural, high cost, low-income and high risk. Serving these markets has required large investments that have not been forthcoming from the private sector. There have been few new entrants on account of the low potential profits, but also because of the high risks and obstacles associated with penetrating a weakly regulated market dominated by a monopoly.

Wireless and VoIP are beginning to change the economic calculus of serving rural areas. But while technology is changing, significant regulatory and governance obstacles remain. There is broad recognition that Government subsidies are required to stimulate demand and spur investment to serve rural communities. The way that these subsidies are crafted will not only impact rural service in the short term, but also the future competitive development of information and communication technologies in developing countries.

This paper gives an overview of the significant role of Wireless and VoIP technologies in expanding low cost ICT services to rural communities in developing countries, highlights the importance of competition between rivalrous networks to increase investment in telecommunications, identifies regulatory and governance obstacles that need to be overcome, and outlines some strategic considerations for crafting donor and government interventions aimed at expanding rural broadband service.

Significance of VoIP and Wireless for Low Income People

VoIP

Core interactive services - voice, chatting, videoconferencing and SMS - are fundamental to rural development. Rural people rely on a complex web of neighbors, public officials, associates, and friends, to obtain valuable and reliable information about income earning

opportunities and better technology. Personalized attention, personal knowledge, confidence, and frequent interaction are fundamental to the sustainability and success of these networks in bringing about technology transfer and social and economic change. (Barrett [2004], Conley and Udry [2005], and Udry and Conley [2004]).[1]

Internet telephony (VoIP) is very valuable to low income users in developing countries. Peru, for example, has a dense network of about 20,000 *cabinas públicas,* (commercial Internet public access points commonly known as cybercafés elsewhere), most of them located in Lima and other urban centers. Open competition in telecommunications and among ISP's and *cabina* operators have led to low service costs. In May-June 2004, 49% of Lima's telecenter users were paying between US$ 0.30 and US$ 0.46 for an hour of computer/Internet use, and 34% were paying US$ 0.30 or less. Peru's *cabinas* are ubiquitous and useful to everyone, but particularly important to low income people. In May-June 2004, the proportion of Lima's population aged 8-70 using the Internet regularly (at least once a month) was 41 percent, and the proportion in the 12-50 age group was 54 percent. [Apoyo 2004]. For the age 8-70 group, Internet use is much higher in the upper (84% for "A" socioeconomic status) than the lower income brackets (37% for "D" and 30% for "E" status); and higher for men (54%) than for women (42%). Most of Lima's Internet users – 88% of those aged 8-70 – connect to the Internet through *cabinas*. But whereas *cabina* use is a matter of convenience for the higher income groups, for low income people they often represent the only access option. Ninety three percent of low income users (D and E) use *cabinas* as their habitual place to connect to the Internet. VoIP is used broadly by all income class users of *cabinas públicas*, but is most highly prized by low-income users (Table 1).

Table 1. % of Peru's *Cabina* Users who Talk on the Phone through the Internet, by Socioeconomic Status

Socioeconomic Status	% of Users
A (highest)	33
B	29
C	29
D/E (lowest)	40
All Users	33

Source: Apoyo [2005]

VoIP is also a major source of income for Nicaragua's 700 cybercafés. For the rural telecenters sponsored by the World Bank sponsored Agricultural Technology Project, VoIP is critical to achieving sustainability, generating about 30% of total service revenues (Proenza [2005]).

Vinueza and Rodríguez (2004) estimated there were 166 formally registered cybercafés in Quito in 2003. Cybercafés are also commonplace in Guayaquil and are also found in Ecuador's larger towns. In Quito, the main purpose for using cybercafés is communications, with nearly 50% of users indicating that keeping contact with family and friends as their main reason objective. VoIP is an important service used by 17.5% of users surveyed.

In Indonesia, a pilot project sponsored by Government installed VoIP equipment in 200 Wartels (the local equivalent of cybercafés) in Jakarta, Bandung, Semarang, Surabaya and Cikarang. The provision of VoIP services enabled the Wartels' to increase their income by 17% from domestic long distance calls and by 43% from international long distance calls.

In India, Best (2003) has estimated that in order to achieve sustainability a Rural telecenter run by the Sari project requires eight times as many customers if voice is not one of the services provided.

Wireless

Wireless technologies are going to play an increasingly prominent role in the expansion of rural telecommunications networks in developing countries (Reynolds and Samuels 2004, Galperin 2004). Wireless technologies have cost advantages for rural service and, perhaps more important, they are better suited to service the demand requirements of rural low income communities **sustainably**,

Bandwidth Requirements of Low Income Rural Communities

Rural service demands are best met gradually, beginning with low bandwidth sufficient to provide basic communications services that people demand the most – e.g. voice, while simultaneously laying the groundwork to expand as incomes and demand grow. The need for high quality networks is not necessary during this initial stage. For example, each of the 2,400 kiosks sponsored by n-logue communications and IIT-Madras operate on CORdect technology with throughput of about 70 Kbps (Table 3). Acknowledging this limited broadband requirement in rural areas[2], the throughput requirements specified by most of the reverse subsidy auctions in South America is in the range of 128 Kbps – 256 Kbps per access point (Table 5).

Cost, Scalability and Ability to Serve Disperse Populations at Low Cost

Telecommunications networks are underdeveloped in rural areas that are difficult to serve on account of rugged terrain, dispersion of customers, and low income and limited ability to pay for services. These are precisely the conditions under which the new wireless technologies have advantages over wire lines.[3] Wireless networks are easy to deploy, easy to upgrade to accommodate increases in demand requirements and they require small investments. (Best 2003, Adythia 2005)

Local Networks, Digital Literacy and Sustainability of Service

Social and economic networks are first and foremost local. People's priority communication needs are with peers located in their vicinity and in neighboring towns. Horst and Miller (2005) show how the ubiquitous cellular phones in rural Jamaica are being used to strengthen existing relationships. Even in a modern globalized country like France, the telecommunications market is essentially local (Table 2).

Table 2. France's Fixed Lines Telephone Market – 2002

	Quantity		Value	
	Millions of minutes	**%**	**Millions of Euros**	**%**
Local calls (excludes Internet access calls)	65,820	60.8%	2,656	33.6%
Long distance calls	27,368	25.3%	1,517	19.2%
International calls	4,704	4.3%	844	10.7%
Calls to mobiles	10,357	9.6%	2,879	36.5%
Total calls from fixed lines	108,249	100.0%	7,896	100.0%

Source: Autorité de Régulation des Télécommunications 2003

Table 3a. Common Land Line Technology Options

Technology Options		Urban	Rural Areas		Typical Throughput		Salient Features
			High Population Density	Low Density-Complex Terrain	Up	Down	
Fiber	**T1**	Backbone Last Mile (FTTH)	Backbone	....	1.544 Mbps		Provides backbone for PSTNs. Investment costs are high, maintenance costs are low. Geographic reach is fixed. Relies on light pulses & is continuously improving in transmission capacity and cost.
	T3				45 Mbps		
	SONET				51- 38813 Mbps		
Dial up copper wire		Last Mile	Last Mile	....	53 Kbps		Outdated PSTN technology being replaced by wire, but still used to expand existing networks in low profit markets.
Cable Modem Access		Backbone, Last Mile	Backbone, Last Mile	....	256-768 Kbps	1.5 - 3 Mbps	Modified Coaxial Cable Technology to provide TV & data services. Modern hybrid fiber/coax systems are more effective.
xDSL	**ADSL**	Last Mile	Last Mile	....	128 Kbps	512 Kbps	Uses copper wiring. Some versions asymmetric (ADSL) other are symmetrical (HDSL, SDSL, SHDSL, VDSL).
	VDSL				1.5 Mbps - 13 Mbps		
ISDN		Last Mile	Last Mile	....	128 Kbps / 1.544 Mbps		Technology standard for transmitting digitally over PSTN.

Source: Dodd (2005).

Table 3b. Common Wireless Technology Options

Technology Options		Urban	Rural Areas		Typical Throughput		Salient Features
			High Population Density	Low Density-Complex Terrain	Up	Down	
Point to Point Microwave		....	Backbone		1.544 Mbps to 155 Mbps		LOS carrier technology using 4GHz and 6GHz (in US). Options are proprietary. US deployment peaked in 1980s, but still used elsewhere. 801.16 expected to achieve low cost through common standards (WiMax).
VSAT		Backbone, Last Mile		Backbone, Last Mile	64 Kbps - 5 Mbps	128 Kbps - 11 Mbps	Serves many disperse sites. Cost is independent of distance, but significantly lower for large # of sites. Latency is addressed satisfactorily for most applications (VoIP). Satellite time is main cost. Scalable - may increase throughput without system changes. Numerous technology neutral subsidy auctions won by VSAT.
CorDECT		....	Last Mile	....	70 Kbps (25 Km pt-multipt.)		Developed at IIT-Madras, marketed by Midas Communications. 2,400 n-logue kiosks rely on wireless CorDECT link from existing fiber lines.
CDMA 2000		Mobile	Mobile-Last Mile	Mobile-Last Mile	153 Kbps		Mobile standard that may also be used to extend fixed wireless connectivity to rural areas (WLL).
WiFi	802.11a	Last Mile			<= 54 Mbps; typical 24 Mbps		802.11b & g operate at 2.4 Ghz, have 3 channels each & cover about 100 feet; 802.11a operates at 5 Ghz band, has 24 channels & covers 75 feet (requires more antennas). Business experiment in Zamora Spain showed complexity of maintaining large WiFi network with many antennas.
	802.11b				<= 11Mbps; typical 5 Mbps (20km pt-pt)		
	802.11g				<= 54 Mbps; typical 12-24 Mbps		
Pre-WiMax	801.16d	Backbone			1.5 -2.0 Mbps (theoretical <= 75 Mbps) NLOS 3 Km in 2.5 Ghz LOS pt to pt 25-35 Km;		Operates in 2.5, 3.5 and in licensed exempt (in US) 5.8 Ghz bands. Intel: "a wireless alternative to the cable modem,... xDSL,…Tx/Ex... And OCx circuits." Equipment meeting the standard expected in 2006; several pre-certification products already in market (802.16d from Alvarion, Motorola, Redline; 802.16e from Netnex).
	801.16e	Last Mile Mobile –(potential)			1.5 Mbps NLOS 3-5 Km LOS 20-25 Km		

Sources: Dodd (2005), Best(2003), Moulton and Moulton (2001), Intel (2004, 2005), Reynolds and Samuels (2004) and Ermanno Pietrosemoli, David W. Mendoza and Bernard Merzer (correspondence).

Government sponsored attempts to extend telecommunications services to serve rural people have generally provided long distance services. Communities have been linked to distant urban and international centers, for example by subsidizing public telephone service in the larger small towns, or by financing the set up of rural telecenters. These are valuable services, particularly for communities with significant migrant populations, but at best meet only a part of the communication needs of rural people and constrains the potential profits attainable from private provision of service.

Where the terrain allows relatively low cost of deployment of mobile base stations, e.g. in island countries like Jamaica and Sri Lanka, mobile telephony has penetrated rural areas very rapidly. New skills are not required in order to use a mobile phone, and mobile telephony's cellular form of deployment facilitate local communications and reinforce local networks.

In contrast, the inability to achieve significant network effects has been a daunting challenge for rural telecenter programs. Most telecenter based rural networks have not achieved a significant mass, in part because they rely on computer literacy of customers that generally have limited education, but also because they provide what essentially amounts to a long distance service.

Shortly after Colombia's first telecenter program (670 telecenters) was launched, officials realized that the centers were hardly being used. COMPARTEL thus funded a parallel program (*Estrategia de Acercamiento a la Comunidad*) that between 2002-2003 trained local leaders in basic computer skills and in the use of computers to support the implementation of community projects. There has been little follow up work, but because the program did not expressly seek to build up local networks, its impact on sustained effective use of the telecenters may have been small.

Acknowledging the importance of computer skills and network effects, digital literacy campaigns have become part of successful national efforts to further ICT development.[4] In Korea, Government carried out mass media informatization campaigns (Park [2001]) and established Education Information Centers in schools and post offices, used to provided free or low cost information education to an estimated 10 million people, mainly students, government staff, soldiers and housewives (Lee [2002]). In Chile, the country's national digital literacy campaign (Gobierno de Chile [2004]) provides for digital literacy training of 500,000 people in 2003-2005 (www.alfabetizaciondigital.cl, www.mineduc.cl/alfabetizacion/). The program runs in parallel with its telecenter program and includes digital literacy training to users of public library telecenter users (www.biblioredes.cl) as well as specific efforts directed at farmers.

ITU's telecenters in Honduras have been using wireless solutions since 2000 to directly address the issue of the dispersion of rural populations. The two headquarters centers (one in Valle de Angeles and the other in Santa Lucia) retransmit Internet signals serving as ISP for neighboring residents, and data at a lower rate (using spread spectrum and radio packets) to low-cost and low-maintenance 1-computer mini-centers located in neighboring villages. Soon after it was instituted this ISP service became the major source of revenue for these telecenters, helping to cover costs for the mother center while keeping the cost of servicing satellite mini-centers affordable.

The standardization of technologies in a widely agreed upon standard, WiFi and WiMax, promises to enable low cost deployment and operation. Much like the ITU experiments in Honduras, the new technologies can help provide broadband connectivity to rural communities and the surrounding environs. They enhance the prospects of rural telecenter sustainability by making it potentially profitable for small operators to function as local ISPs. Herein lies their real power: the potential to strengthen local communication networks at low cost. For their promise to be realized, important regulatory constraints will need to be overcome.

The Regulatory Challenge

Given their importance for serving low income communities, it would be sensible to expect for developing countries to pursue an aggressive policy of enabling widespread use of VoIP and wireless technologies. This is sometimes the case but hardly the norm. Widespread adoption of these technologies is often blocked, particularly in countries where incumbent telecom monopolies or cartels capture regulation and policy.

Beyond their economic significance and advantages for serving rural communities, VoIP and wireless are important for competition policy. Wireless networks enhanced by the ability to provide Voice services over the Internet can potentially enable new operators to challenge the dominance of incumbents' land line networks.

VoIP

Some countries see VoIP as an innovative technology that increases competition and a way to lower costs and increase consumer surplus. The US's follows a minimal regulation approach (http://www.fcc.gov/voip/), requiring only basic quality standards, such as the provision that VoIP phones be able to connect to the national 911 emergency number. Canada's regulator has adopted a more aggressive asymmetric stance, allowing new entrants to the telecommunications market to provide VoIP services connecting to the PSTN, but continuing to regulate the incumbents VoIP service offers to prevent predatory pricing from stifling competition (Charny [2005], CRTC [2005]).

The situation is quite different in developing countries, where restrictions on VoIP frustrate the development of IP based networks and the provision of services valued by low income people.

Table 4 shows SkypeOut rates and various indicators of VoIP regulation for 22 countries - most in South America, plus a select few in Asia and from the OECD. Skype has broad country coverage and a large number of subscribers world wide. SkypeOut rates are for VoIP service from PC to PSTN telephones and are largely determined by interconnection charges of incumbent national operators (Dodd 2005, page 179). They are influenced by regulatory policies and by the ability of incumbents to capture monopoly rents.

The base SkypeOut rate is for international calls to the UK, the US, and Canada, and is equal to US$ 0.021/minute. Calls to some developing countries with an open regulatory regime, e.g. Chile, also achieve this low rate. Countries with vigorous competition like Korea also achieve low VoIP rates (US$ 0.025/minute; 18% higher than the base rate).

The 13 countries with the highest SkypeOut rate (i.e. those ranked 7 through 18) may be characterized by weak regulation or by the purposeful protection by Government of the incumbent's telephone revenues. Guyana tops the list with a rate of US$ 0.40/minute, which is higher than the base rate by 1,700%. In Guyana, the monopoly carrier does not allow VoIP calls through cybercafés using their services. Some Guyanese ISPs using wireless technologies are competing and providing VoiP services, but are challenged by the regulator.

The other 12 countries in Table 4 with SkypeOut rates that are higher than the base rate by over 300% include 2 that ban retail VoIP services (Bolivia and Paraguay), 2 that specifically prohibit commercial provision of domestic VoIP call services (Ecuador, India), 2 in which the State has a high stakes in the country's incumbent operator (Honduras, Sri Lanka), 4 with restrictive licensing requirements for commercial VoIP service (Mexico, Indonesia, Colombia, Dominican Republic), and 2 where the telecommunications sector has only recently been opened up to competition (Jamaica and Nicaragua).

Table 4. SkypeOut Rates and VoIP Related Regulation in 22 Countries
(Page 1 of 2)

Region / Country	Skype - SkypeOut Rate* (US$/Min)		Rank	Notes on VoIP and Related Regulation **
	US$/ min.	as % of US-UK Rate		
Argentina	0.032	53	3	Resolution 764/2000 of the Secretariat of Communications states that VOIP services are a free telecommunications service in competition in Argentina. No restriction on provision of VoIP.
Bolivia	0.149	606	12	Only holders of long distance carriers are allowed to provide VoIP. Retail sale of VoIP services is illegal (Nieminen 2004, Beal 2004)
Brazil	0.055	159	5	VoIP services are allowed. There are no specific regulations or legislation pertaining to VoIP in Brazil.
Chile	0.021	0	1	Commercial service of VoIP is subject to ordinary licensing requirements as any other telephone service. There is no regulation of PC to PC VoIP or of PC to the national telephone network. Regulation of calls that start from the public telephone network to Internet phones is under review.
Colombia	0.095	353	9	Licenses are issued by the Ministry of Communications according to the regulations currently in force, specifically Law 142 of 1994 and Resolution 087 of 1997. Licenses are prohibitively expensive and only incumbent operators have them.
Ecuador	0.178	747	15	Commercial VoIP is allowed only for international but not for national calls.
Guyana	0.378	1,694	18	Incumbent claims a 20 year monopoly with a right of extension for another 20 years. Only incumbent is allowed to provide VoIP, but "rogue" operators do so.
Honduras	0.364	1,629	17	State owned monopoly controls wire lines.
Jamaica	0.126	500	11	Jamaica is in an advanced stage of telecom market liberalization. License is required to provide commercial VoIP services.
Mexico	0.099	371	10	The Regulator, COFETEL, classifies a VoIP provider as an illegal carrier if it is not properly licensed or not making contributions to universal service funds.
Nicaragua	0.217	929	16	Exclusivity period granted to privatized incumbent, ENITEL, ended April 2005. VoIP has been banned (Horvitz 2002), but regulation may change with market opening.
Paraguay	0.151	618	13	Commercial provision of VoIP services are illegal. ISP access to fiber network is only through State monopoly incumbent COPACO.
Peru	0.079	276	6	The policy consensus is that commercial exploitation of VoIP should be regulated for calls initiated or ending in the public telephone network. In practice there is no explicit regulation and VoIP has been deployed extensively.
Dominican Republic	0.088	317.6	7	To provide commercial VoIP services an operator must obtain a carrier license from INDOTEL.
Venezuela	0.052	147	4	Licensing is required for commercial provision of VoIP.

Table 4. SkypeOut Rates and VoIP Related Regulation in 22 Countries
(Page 2 of 2)

Region /Country	Skype - SkypeOut Rate* (US$/Min)		Rank	Notes on VoIP and Related Regulation **
	US$/ min.	as % of US-UK Rate		
India	0.155	635	14	PC-to-PC calls are allowed to both domestic and international destinations, but PC to telephone calls are only for domestic to international calls. Quality of Service (QoS) requirements also apply.
Indonesia	0.093	341	8	ISPs wanting to provide VoIP service must use the few licensed operators and new licenses are issued sparingly As of Sep. 2004, there were 7 VoIP licensed operators.
Republic of Korea	0.025	18	2	Korea encourages facilities based competition and establishes a separate class of telephony channeled through the Internet. The two main telecom operators are also important players in VoIP offerings.
Sri Lanka	0.141	606	12	Cartel charges prohibitive interconnection charges to PSTN and thus restricts commercial value of VoIP. Incumbent Sri Lanka Telecom is 49% owned by Government, raising potential conflict of interest and possibility of regulatory capture.
US	0.021	0	1	A May 19, 2005 FCC Order obligates commercial VoIP service providers to enable customers to deliver all 911 calls to the customer's local emergency operator as a standard feature of the service.
Canada	0.021	0	1	Asymmetric regulation adopted to foster competition in local telephone markets. VoIP is regulated only when it is provided and used as local telephone service. Incumbent carriers with market power cannot price their local VoIP services below cost to stifle competition.
UK	0.021	0	1	Any operator may provide VoIP without restrictions.

Notes:

** VOIP Regulation information for Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, India, US, and UK is from the Global IP Alliance, www.ipall.org/matrix/
Information for the other countries considered have been gathered by the authors.

* SkypeOut Rates are those effective 8 August 2005 (www.skype.com/products/skypeout/rates/).
Rate given is general countrywide rate. In general, urban rates are lower and mobile rates higher than countrywide rates. 1 Euro = US$: 0.807

The fight over VoIP can be fierce. In Indonesia, there were an estimated 120 ISPs providing VoIP service in 2000, but in 2001 the Government started regulating the number of VoIP operators and arrested the directors and confiscated the equipment of many ISPs who were providing the service. (Sulaiman 2003, page 21.) Indonesian ISPs wanting to provide VoIP service are required to do so through the few licensed operators (Roes 2003), and additional licenses are issued sparingly (Sulaiman 2003). As of September 2004, there were only 7 VoIP licensed operators.

Wireless

Licensing

Information is sparse with respect to regulations on the use of bands that in the US and Europe are license free and that are fundamental to widespread deployment of Wireless technologies like WiFi and WiMax. Neto, Best and Gillet 2004 uncovered great

heterogeneity in 47 African countries surveyed. Only in three counties, Rwanda, Lesotho and Tunisia, was the 2.4-2.4385 Hz band "license free", in the sense this term is used in the US and Europe of requiring no license or registration; and only in Rwanda and Lesotho was the 5 Ghz (5.15-5.35, 5.47-5.725, and 5.725-5.875) band license free. In all other countries a broad range of restrictions potentially limit the use of these frequencies with respect to power, range and licensing. Galperin (2004) examines the situation in Chile, Peru, Mexico and Brazil, and finds restrictive regulatory requirements (e.g. outdoor use barred) for the 2.4 Hz band, with the exception of rural areas in Brazil.

Interconnection

Beyond licensing, traditional operators servicing a sizeable network will reject interconnection or extract high fees for access to its customers by rivalrous Wireless networks, in a concerted effort to protect or strengthen its dominance and profit margins (Jensen 2005).

Sri Lanka's experience helps illustrate. Sri Lanka has a partially privatized telecommunications sector, but Government owns 49.5% of SLT (the incumbent land line operator) shares. NTT Communication Corporation of Japan owns about 35.2% and the balance is owned by the public. This shareholding structure of the dominant operator differs significantly from countries like Peru, Chile and Brazil, whose regulators are generally praised for their expertise and independence and where the State has no stake in the dominant carriers. Sri Lanka's Government direct interest in the economic well being of the incumbent operator has the potential to compromise the independence of the country's regulator, the Telecommunications Regulatory Commission of Sri Lanka.

The performance of Sri Lanka's regulator has been rated as unsatisfactory, particularly with respect to interconnection by local observers, for example during the period 1997-2000 (Samarajiva and Dokeniya 2004). Outsiders with a commercial interest in a more open telecommunications market are blunt in their assessment. According to the 2005 report of the Office of the US Trade Representative (page 581):

> "A key problem facing the telecommunications sector is restricted interconnection. The Regulatory Authority has failed to enforce regulations provided under the Telecommunications Act to establish an efficient and transparent interconnection regime. SLT, the wireless operators and some of the mobile operators have formed an unofficial cartel to control local gateways and restrict interconnection for other operators. This has adversely affected the operations of most of the other operators and new international gateway licensees who are unable to make use of their licenses due to lack of interconnection by the local exchange operators. This situation has resulted in illegal bypass by some operators. Spectrum management is also weak and frequencies are not properly allocated which affect telecommunication operators. The Regulatory Agency, under a new management, has plans to improve the regulatory regime."[5]

The incumbent interconnection practices have had a direct bearing on rural ICT development. The e-Sri Lanka Development Project provides for the establishment of 200 rural telecenters throughout the country (World Bank 2004). At appraisal, a study of existing cybercafés (which receive connectivity from the incumbent operator) showed telephone service to be an important source of revenue, and it was assumed that the same would be true of the rural telecenters to be established by the project. This expectation has not materialized. The open bid to provide connectivity to the centers was won by a VSAT operator, but the terms of interconnection to the PSTN that has been achieved is high cost. The cost of local calls in the project sponsored telecenters (about 80 established to date) are too high and revenues from telephony are negligible.

Interconnection agreements are determined by the relative power of the negotiating parties. An incumbent serving a large network wields considerable power, including the power to influence policy and regulation. Consumers are affected adversely, but their interests are diffused and their ability to access and to assess the pertinent information is constrained. A regulator's capabilities, independence and power to make interconnection effective does not change over night or by decree. Only a challenge from other operators with large (or potentially large) rivalrous networks will achieve interconnection at reasonable cost.[6]

Broadband Development

Facilities based competition is the avowed objective of modern regulators, e.g. in the US, Canada, the European Union, Korea and Chile (Coloma and Tarziján 2002). Facilities based competition requires less State intervention and stimulates innovation. In practice, the possibilities for implementing facilities based competition are constrained by technology options and market potential.

Facilities based competition works well in urban environments, where the size of the market enables competitors to invest in network development and be profitable by serving a share of a market comprised of a large customer pool. In developing countries underserved areas are primarily comprised of low income rural communities dispersed over a wide geographic area. Competition is limited by the size of the commercially viable market.

Regulators in developing countries are key determinants of investment risk. While it is possible to identify conditions that should be met for good independent regulation; obtaining such independence in practice has more to do with changing cultural mores and local tradition; i.e. factors that are difficult to change. There are also legitimate concerns of local populations that need to be addressed; e.g. the desire to have local standards to stimulate local innovation and profit from the development of the local industry. Most importantly, with little profits to be made from rural markets there are no prospective new market entrants interested in challenging the incumbent's potential dominance.

The thrust of telecommunications investments today is on delivering broadband and related services. Some commercial interests in developing countries are making plans to deploy wireless networks (WiMax-UK 2005). To reach rural communities, however, Government subsidies are needed to build up demand and stimulate private investment. Three different experiences with Governmental efforts to develop broadband are reviewed below, in search for lessons for developing countries.

Korea – An Urban Model

South Korea's achievements are well known and the country is often regarded as a model to be reproduced in other countries. South Korea has a high income but it is a large country of 40 million people with one of the highest rates of high speed connectivity in the world. About 43% of Korean households are connected to an average of 4 Mbps (ITU [2003]), and pay only about US$ 50/month (ITU [2004]).

What is not as well known is how Korea got to its present prominence. What is it that accounts for Korea's success?

> First, the government helped develop the backbone by becoming the major client for broadband services (KII-G). Before competition began in earnest, the country was well served with fixed wire telephony. From 1995-1997 Government gave loans to the two facilities based service providers, KLT and DATACOM, to roll out fiber to serve 80 cities. In exchange, the operators repaid these loans by

providing connectivity service to 10,000 government offices (Tcha et al [1999], page 6). The operators were allowed and encouraged to establish their own private service network alongside but were required to lease their facilities to new entrants at a pre-determined government price.

Second, the dramatic fall in prices and fast broadband roll out was the direct result of facilities-based competition actively promoted by the State. Thrunet began to offer cable modem service in July 1998. Then in April 1999 Hanaro offered optic ADSL and cable modem service. KTL had been promoting ISDN to profit from its infrastructure, but, threatened with a loss of market, started offering copper ADSL in December 1999 (Lee [2002]). At present, seven facilities-based operators offer customers various options. About 90% of Korean households have access to broadband through ADSL, and 57% through cable modem. Apartment LANs and wireless technologies cover 9%.

Third, Korea is highly urbanized. Eighty percent of the population lives in cities or large towns. Apartment buildings of 600 units and more are commonplace. A dense population makes the fast roll out of broadband infrastructure a low-cost undertaking. Construction companies own the local area networks in buildings, and government helps through a certification system that rates Apartments according to broadband speed (Yun, Lee and Lim [2002]).

Fourth, demand encouragement by Government and operators has been vital. Economic crisis befell the country right after the big broadband expansion. Multi-layer online gaming – more than 21,000 PCBangs as of 2001, helped absorb the broadband and stimulated residential demand (Lee and Choudrie [2002], Aizu[2002]). Government also carried out massive informatization campaigns focused on key target groups (e.g. students, government, the military and housewives).

Korea is a good model, but it is not perfect. Overcapacity fiber was laid out and this overcapacity was taken up by PC Bangs. While connectivity for social and economic development is worthwhile, the creation of overcapacity fiber to be used for gaming is not the most desirable option.

Korea's income per capita is much higher than most developing countries today (US$ PPP 16,950 in 2002 UNDP [2004]). Korea's population is 80% urban. A higher income increases the capacity of the market to bear the costs of broadband deployment; while a less concentrated population makes the cost of such deployment more expensive.

South Korea's experience, with the key role played by the State, its emphasis on stimulating the development of rivalrous networks and on the need to build up demand through basic ICT literacy, deservedly serves as an inspiration for developing countries. It is nevertheless important to recognize that it is an urban model developed in a high income country; and that these features limit its applicability to infrastructure development in rural low income environments.

South American Experience with Reverse Subsidy Auctions

Experience with reverse subsidy auctions started with rural telephony in Chile, but as digital networks and IP protocols have become commonplace, "universal service" objectives have been broadened to include voice, data and multimedia services. Table 5 presents a summary of some recent reverse subsidy auctions in South America. Several involve the establishment of telecenters, but others provide broadband and telephony to communities, schools and public agencies.[7]

Several features of the reverse subsidy auction approach account for its popularity. First, it is a market driven approach. It stimulates private investment by making firms compete for the subsidy awards, and ultimately relies on the private sector to provide the services. Second, when properly carried out (and this is not always the case), it is a transparent approach: every company and every member of society is able to obtain information on the process, understand clearly what will be required of the winning bidder, and ask for clarification and effect changes during the consultation process prior to bidding. Third, it facilitates fiscal discipline. Some very remote areas are very difficult and costly to serve, and at times have to remain beyond the means of even the most well meaning Governments. The reverse auction methodology enables countries to decide a priori the maximum amount of subsidy they are willing and able to afford.

A fourth very important feature – but one that is not always appreciated - is that reverse subsidy auctions can help foster competition by enabling new entrants in the telecommunications markets establish wireless networks in rural areas that begin to compete with established incumbent networks. To do so, however, careful crafting of the auction design is indispensable.

Contest Design and Risk Management

The risk perceived by firms is a critical determinant of the subsidy requirement of bidders. In places like Colombia, the risk of sabotage or attack by insurgents is high and the number of bidders is small. Consequently, the subsidy awards have also been high (US$ 29,000 – 80,000 per telecenter – see Table 5).

Given the specialized and complex expertise involved, the magnitude of investments, and the risks associated with rural service, the number of bidders that participate in reverse auctions is generally small. In thin markets, the maximum subsidy requirement in an auction is a strong signal to bidders that they often approximate in their bids. It is not uncommon for only one bidder to show up (e.g. Colombia 2nd tender; the majority of networks served under Chile's 2nd Infocenter tender) or for no bidder to show up.

It is important to provide bidders with as much information as possible, to lower the risks and thus lower the amount of subsidy that bidders will feel is necessary to provide the services. It pays for the State to carry out preliminary surveys in order to specify the towns to be served, the basic features of these towns, and the number of connections and quality of service requirements. Programs should first focus on larger towns, and avoid the temptation to service the poorer, smaller, more remote villages. Measures that reduce operator uncertainty also help, such as for example expanding the service area gradually, taking advantage of local knowledge, and testing the market with a relative small initial program that gives operators the opportunity to learn and understand costs and risks involved with rural service.

Table 5. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean

(page 1 of 3)

Country & Date of Tender	No. of Points of Service	No. computers/ Centre	Connection speed/Cost	Status
Chile Population 18.7 million GDP/cap (US$ppp)= 8652 Literacy rate= 91.4 HDI rank 81 (index= .735)	**centre/ Cluster** / **No of clusters** / **No. of centers** 4 / 2 / 8 5 / 3 / 15 6 / 7 / 42 7 / 6 / 42 8 / 9 / 72 9 / 6 / 54 10 / 2 / 20 **35** / **253**	at least 4 computers (at least 1 with CD burner) minimum space of site where computers are to be placed: 20 m^2	Minimum speed **128 Kbps** between tele-center and ISP (both ways); plus 32 Kbps for each additional computer installed. Price fixed at customer level. 209 centers awarded: 65% wired technologies (dial up, ADSL, ISDN and dedicated line); 35% wireless (mostly VSAT but also some GPRS and WLL)	- This is Chile's 2nd Tele-center program; presently under execution.
	Rural Schools Connectivity 2004 667 Rural Elementary Mid-level Schools serving 108,646 children, Participating schools have to enable service to the community	Number of PCs/school (1-36) depends on school size (10 – 1000 children).	Small schools: minimum speed of 64Kbps downstream & 32 upstream; Large: 256 Kbps downstream, 128 Kbps upstream. Free service to schools for 3 years. Subsidy of US$ 6,650,000 awarded to 2 companies; one serving 530 schools with VSAT (Hispasat Ku Band, DVB-RCS); another serving 137 schools with WiFi. Subsidy per school (about $10,000) and per student ($61) is similar for both companies.	Tender awarded end of 2004. Project under execution.
Brasil (2003-2004) Population 174.1 million GDP/cap (US$ ppp)=7360 Literacy rate = 87.3% HDI rank 75 (index= .777)	3,200 telecenters	Average of 5 computers per center.	Broadband 256 Kbps service using VSAT, Free of charge to users and local operators over 22 month service period.	Project under execution 2003-2005.

Table 5. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean

(page 2 of 3)

Country & Date of Tender	No. of Points of Service	No. computers/ Centre	Connection speed/Cost	Status
Colombia COMPARTEL Population 41.4 mill GDP/cap (US$ppp)= 5749 Literacy rate= 95.3 HDI rank 62 (index= .765)	1st Tender Public Telephony & Internet Access Points 6,745 public telephones in small towns with less than 250 people 670 Internet centers	Each telecenter equipped with 1 computer & 1 printer.	Minimum navigation speed: 1 Kbps. User price fixed at US$ 1/hour. Estimated subsidy per Telecenter US$ 9,230 Winning bidder was Gilat using 70% VSAT and 30% cellular technology.	Awarded in March 2000. Operation and maintenance contract is for 10 years.
	2nd Tender – **Social Internet** 261 telecenters contracted, but 285 were installed by operator at own cost.	3 computers in cities with < 30,000 6 in cities with 30,000 to 200,000 12 in cities with over 200,000 Subsidy award: US$ 29,000/center	Minimum effective navigation speed/pc: 4 Kbps. User price fixed at US$ 1/hour. Subsidy: US$ 28,900/center. Awarded to land line incumbent who nevertheless uses VSATs (Hughes) for these centers.	Under execution by Moreno S.A. - Telefonica Data. since mid 2001. 5 year contract ends October 2006
	3rd Tender – **Telecenters** 500 telecenters in small towns: 30% > 2,000 people; 56% with 2,000-5000 people; 13% with 5,000 to 10,000.	2, 4 or 6 public telephones in each telecenter and up to 3 public phones located in public institutions (mayor, police station, hospital, health clinic); 8 computers per center (1 for administration) training room for 20 people + training of users & variety of services	Minimum effective navigation speed per PC 7 Kbps; Contract was awarded to soul bidder, Gilat (VSAT manufacturer). Subsidy award: US$ 80,000/center (including public telephone service, training, etc.)	Under implementation since 2003. Service contract is for 6 years.
	4th Tender Broadband for **Public Agencies** 3,000 schools, 624 local gov., 120 hospitals and 30 military garrisons.	1,372 with 3-4 computers 592 with 5-8 computers 691 with 9-12 computers 1,119 with 13-16 computers	**No. PCs** **Access**(kbps) **Down** **Up** 3-4 128 48 5-8 128 64 9-12 256 96 13-16 256 128 Awarded to COMSAT Int.-Inalambrica Internet Colombia-VSAT Technology; Subsidy: US$ 11,620/public agency.	Tender issued March 2004;Awarded 2004. Service Contract is for 6 years. 2nd Tender to be awarded Nov. 2005.

Table 5. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean
(page 3 of 3)

Country & Date of Tender	No. of Points of Service	Computers/Centre	Connection speed/Cost	Status
Guyana (2002) Population 0.8 million GDP/cap (US$ppp)= 3640 Literacy rate= 98.4 HDI rank 93 (index= .704)	33	3 computers per centre	One VSAT serving 4 – 5 connect points, one of which is a tele-center (reference network). Cost to tele-center: **US$ 170/month** (set to be equal to cost of connectivity system operation)	IADB pipeline project (2002). Cancelled as result of incumbent efforts.
Peru – Sept. 2003 Population 25.2 million GDP/cap (US$ppp)= 4622 Literacy rate= 89.6 HDI rank 73 (index= .743)	818	Minimum of one computer per centre.	Minimum speed of **64 Kbps** per tele-center. (Commercial rate of dedicated line to urban tele-center in November 2000: **US$ 476/month**)	This is second consultation round (late 2003). Project partitioned into phases (see 1st Phase in next entry)
Peru – District Capitals – 1st Phase (2005)	68 District Capitals	68 Access points, each with 3 data ports, one to serve a local telecenter (equipped with at least 1 PC).	Each District Capital served by 3 Ethernet 10/100 Base T ports with Internet access (IP Protocol). Minimum speed per port will be 128 Kbps, with maximum asymmetry of 4:1 (uplink speed to downlink speed). The winning consortium will use VSAT (Hughes IPOS) technology with 256/128 Kbps Internet. Subsidy award = approx. US$ 1,000,000.	Tender announced in 2 February 2005 and awarded 25 July 2005. Service contract is for 4 yrs.

Sources:
Data on population, GDP/cap, adult literacy, and Human Development Index (HDI) are for 2001 as reported in UNDP 2003.
Reverse subsidy auction data are from original tender and project documents, and invaluable assistance from Marcel Silva (Subtel), Carlos Sánchez (FITEL) and Nicolás Silva (COMPARTEL).

The State can use its own knowledge of local conditions and through careful design of its contests keep subsidy awards in check (IADB 2003, Vol. IV, page 275). For its second telecenter program Chile first estimated service requirements for the 253 communities to be served and then grouped these communities into 35 "networks" – each made up of 4 to 10 telecenters - that could in principle be served by a single entity or consortium of local operators. Operators could make offers to run any assemblage of these networks. Government then estimated expected costs of service, and identified which of these inputs did not require subsidization, either because they could be provided by having communities assume the cost of the service or through partnerships with local government or community organizations. The cost of providing these inputs were then shaved off the maximum subsidy award allocations.

The procedure weeded out some bidders and resulted in some vacant networks – out of the original 253 to be served, prospective operators made bids for only 209; but an overall low subsidy award was achieved. Whereas in a first pilot project the subsidy awarded to the Universidad de la Frontera (UFRO) amounted to US$ 28,000 per center to run 5 centers for one year, the same institution accepted a significantly lower subsidy amounting to only US$ 14,000 to run each of 6 telecenters over a 5-year period. Why did the same institution accept the much lower subsidy? Because by the time that the second contest happened, it had a much better grasp of the risks and costs involved, and it had learned to make alliances with other local actors to share the running costs.

Peru has carefully crafted its broadband for District Capitals program in order to manage risks. The ultimate objective is to provide broadband services to about 900 District Capitals spread throughout the country. Since 2002 the program has gone through several iterations – each of these amply discussed by society in the web pages of the telecommunication development fund manager (OSIPTEL-FITEL). The first tender was issued in 2004 and, as a first phase test of the approach, it only covered 68 sites. In each site the contractor is expected to provide 3 Ethernet 10/100 Base T ports with Internet access (IP Protocol) and minimum speed per port of 128 Kbps, with maximum asymmetry of 4:1 (uplink speed to downlink speed). One of these ports will provide connectivity to a local telecenter, and the other two are to be marketed by the contractor.

Technology Neutral Contests Favor Wireless for Rural Areas

All of the South American reverse auction contests have pursued "technological neutrality". All have specified service requirements, and those requirements have been modest, commensurate with low broadband requirements of rural populations (generally up to about 256 Kbps download throughput per access point). None of these contests have limited technical options or published in tender documents any kind of network as a reference. Nevertheless a clear pattern emerges in which wireless technology wins out. The main winning solution is VSAT, but some of the newer technologies including WiFi and VSAT with DBR- RCS are beginning to show as winners. The dominance of VSAT in these contests has been noted by Proenza (2001), Door (2003) and Intelecon (2005), and may be clearly appreciated from Table 5.

Incumbents do not Like Reverse Subsidy Auctions

Legacy operators see transparent competitive reverse subsidy auctions as a threat that can help strengthen rivalrous networks and put in jeopardy their market dominance. Where regulatory and legal conditions allow it, they will thwart implementation or seek to take control of the process.

In 2000, the Inter-American Development Bank approved a technical assistance project to support the Government of Guyana in its efforts to liberalize the telecommunications

sector. A parallel loan project prepared in 2002 would fund a reverse subsidy auction to expand rural connectivity in the countryside. The incumbent monopolist sought to derail both projects, including through a legal challenge in US Courts to prevail on the US Treasury to stop the loan. Although the US Court overturned the case, both projects have been cancelled. (Stabroek News 2002a, 2002b, 2004, 2005).

The e-Sri Lanka project approved in 2004 provides funding for the establishment of two regional telecommunications networks, one to provide broadband service to the North of the country and the other one to serve the Deep South, both to be funded following a reverse subsidy auction. Implementation of the RTN component is being challenged in court by a group of license operators that includes the incumbent.

Risks Remain High

Reverse subsidy auctions provide no guarantee of success, particularly with respect to the provision of services that go beyond telephony (e.g. telecenters, broadband). The terrain and limited market (disperse population, limited education and computer skills, limited network effects) associated with rural service are formidable challenges, and many things can and at times do go wrong during implementation.

For example, thirteen of the networks that were awarded by Chile's second tender in 2003 (Table 5) are not in operation. Most troubling, the post project sustainability of many of the telecenters established by reverse auctions in South America, remains an open question. It is not clear that after several years of subsidized operation the various telecenter programs that have been established will achieve sustainability.[8]

Nibbling at the Edges

Technology is driving competition at the edges. Wireless and VoIP technologies are beginning to put in the hands of consumers, small companies and social activists (through easy to install, easy to use, low cost customer premise equipment) the means to connect to IP Networks; at times challenging, at times circumventing and at times changing the regulatory environment. The two examples that follow help illustrate.

India's Chiraag

The Department of Electrical Engineering of IIT-Madras (www.iitm.ac.in/) and its research group (www.tenet.res.in/) is dedicated to bringing ICT services to all of India's villages. Their work covers: i. Development of applications that add value to the ICT experience of low-income rural users; and ii. Incubation of business enterprises, based on the commercial exploitation of the technologies developed. The Tenet website (www.tenet.res.in/Activities/Products/index.php) describes the principal technologies developed, which include: i. Wireless connectivity CorDECT technology developed and commercially exploited by Midas Communication Technologies (www.midascomm.com/). CorDECT functions as a telephone exchange to distribute Wireless connections (Table 3b); ii. Low bandwidth videoconferencing system that enables medical consultations, agricultural technical assistance online, distance learning and interactive communications; iii. Medical diagnostic kits to serve rural communities remotely; iv. Banking teller machines suitable for rural service.

One of the enterprises launched by the Tenet group is n-logue Communications (www.n-logue.com/). n-logue has installed 2,400 rural kiosks, each equipped with a computer, a digital camera and a printer. n-logue runs as a three-tired commercial franchise. In order for each kiosk in the franchise to be sustainable, company officials estimate that each kiosk should earn an average of about US$ 90/month. This is a low value, achievable in

India where the optical fiber network reaches close to many villages, but also thanks to CorDECT technology.

n-logue's work is showing: i. that rural telecenters providing limited bandwidth at low cost can be commercially viable; ii. the importance of combining access with the development of suitable applications that address the specific needs of the poor, and iii. that, contrary to popular belief, the rural poor can afford and are willing to pay for telecenter services that are of practical value. (Table 6).

Table 6. Price List for Chiraag Kiosk Services (n-Logue, Madras)

No	Name of Product/Service	Unit	(US$)
	Education		
1	Blue Certified Computer Course (6 – 9 yrs)	Per student	1.72
1	Blue Plus (6 – 9 yrs advanced)	Per student	5.74
2	Green Certified Computer Course (10 – 16 yrs)	Per student	2.30
3	Red Certified Computer Course (17 & Above)	Per student	6.89
4	Spoken English	Per student/month	5.74
5	Online Test and Tutorial for Class 10	Per student/month	0.69
6	Chiraag Children's Centre	Per Student for 2 weekdays, Sat & Sun	0.23
	Careers		
1	Chiraag Resume-maker	2 sets of printouts	1.15
	Chiraag Studio		
1	Color Passport Size photographs	Set of 5 Nos 1 Photo	0.46 0.11
2	ID card with lamination – single	1 no.	0.34
3	ID card with lamination – bulk order	1 no.	0.28
4	Visiting card	1 no.	0.28
	Browsing		
1		1-15 Minutes	0.23
2		16-30 Minutes	0.34
3		31-60 Minutes	0.57
	Email		
1	Email – text	1 mail	0.23
2	Video Mail	1 mail	0.34
	Queries to Experts - email or Video-conferencing		
1	To government officials		
2	Health		
3	Agriculture	Per Query or Session	0.23
4	Veterinary		
	Astro-Vision		
1	Lifesign Full Horoscope	40 pages	4.13
2	Lifesign Horoscope with predictions	25 pages	2.99
3	Lifesign Basic Horoscope (charts)	16 pages	1.84
4	Lifesign Single Page report	1 page	0.57
5	Horoscope Matching (Porutham)	40 pages	0.69
6	Numerology	8 pages	1.38
	Matrimonial		
1	Entering profile	Per profile	1.15
2	Viewing Profiles	As per time used	

Source: Courtesy of n-Logue Communications; www.n-logue.co.in

Chiraag kiosks derive an important part of the income by relying extensively on interactive communication services such as email, videomail and on videoconferencing technology (e.g., for distance education, queries to experts), in lieu of local telephony which they are not legally allowed to provide.

Indonesia's WiFi Networks

Indonesia's Directorate of Technical and Vocational Education (DTVE) of the Ministry of National Education is executing an important program of 'block grants" to qualifying schools to help fund the establishment of ICT Centers which draw wireless connectivity and help connect neighboring (mainly secondary) schools within a district (Priowirjanto 2005). The program aims to establish 100 such ICT Centers in 2005.

The program relies on local initiative, and involves not only public schools but also qualifying private schools. The Center for ICT Studies in Jakarta (www.ictcentre.net), is part of a private Tourism school. The Center is staffed with a dedicated young cadre of instructors highly qualified in Wireless and VoIP technologies who have set up an ISP and are presently serving, on a commercial basis, 20 Warnets within a 30 km radius. The Center also serves as a training facility to school teachers, on the Administration and Management of WiFi Networks. It is estimated that an additional 18 school based WiFi networks are already operating, about 60 percent also providing connectivity to neighboring access points, and a few located in rural areas.

The Center for ICT Studies started operating on the legal fringe in Indonesia. Vigorous lobbying by the project's promoters – individuals within the Ministry of Education and private technology activists (White 2003, Robitaille 2003, Purbo 2004) – has led to the liberalization of the 2.4-2.483 Ghz band on 6 January 2005 (Minister of Communication 2005). The decree is temporary (2 years) and the proscription on interconnection by 2.4 GHz networks to the PSTN remains in effect. Nevertheless, the liberalization of the 2.4 GHz band is reportedly leading many Indonesian ISPs to shift to wireless networks.

Strategic Considerations for Rural Broadband Development

Institutions and Instruments

What can stakeholders do to spur investment in telecommunications infrastructure in low profitable areas at a low cost? The short answer is **to foster competition and provide smart subsidies to stimulate investments that enhance the prospects of sustainability of broadband service to underserved rural communities.** In practice, donors, policy makers, entrepreneurs and social activists will rely on a variety of instruments, which may be grouped into 4 broad categories:

I. Subsidies to stimulate investment to serve unprofitable (mostly rural) areas.

IIa. Institutional strengthening, to help countries improve regulatory framework.

IIb. Regulation Support, to address critical hot topics: the liberalization of Wireless and VoIP.

III. Build-up of Stakeholder Capacity, to broaden effective lobbying and increase competition at the edge.

The effectiveness of each of these instruments depends largely on the regulatory setting. What will work in one environment may not work and even do harm in another. If the wrong instruments are used, at best a waste of valuable resources will occur, at worse considerable damage will be done by thwarting competition and enhancing the value of the network and hence the power of an incumbent monopolist.

A stylized summary of regulatory settings, with two extremes depicted, is given in Table 7. The bottom part of the table is a subjective assessment of the relative effectiveness of a limited but commonly used policy instruments.

Table 7. Stylized Features of Institutional Setting and Potential Effectiveness of Select Policy Instruments

Stylized Features of Ideal and Challenged Institutional Setting			
	Ideal	**Middle**	**Weak**
Institutional Status of Regulator			
Independent, transparent, accountable, supported by legal system	**X**		
Rivalrous networks compete for a share of the telecommunications market	**X**		**X**
A few operators dominate the market			**X**
Captured regulatory process			
Status of Regulatory Hot Topics			
VoIP is legal, interconnection fo PSTN is cost-based	**X**		
2.4 and 5.8 GHz bands have minimal licensing and use restrictions	**X**		**X**
Vague or Restrictive regulation			
Stakeholder Participation & Monitoring			
Diverse and well developed	**X**		**X**
Rare, poorly informed and unqualified			
Effectiveness of Policy Instruments Depending on Regulatory Setting			
	Ideal	**Middle**	**Weak**
Instruments			
Reverse subsidy auctions	**I**		
Subsidies to build up didital literacy and enhance network effects.			
Subsidies to develop applications for rural service to the poor.			
T. assist. to liberalize market and improve regulatory framework		**IIa**	**IIa**
T. assist. focused on hot topics: Wireless, VoIP		**IIb**	
Build up of stakeholder capacity	**III**	**III**	**III**

In an ideal setting the regulator is fairly independent and makes decisions in the interest of the general public discounting pressures from politicians and from operators. It is supported by a legal system of formal and informal norms that helps resolve disputes fairly and swiftly. Hot topics are addressed soon after they arise. The rise and implementation of emergent technologies like VoIP and Wireless are valued for their potential impact to increase competition in the telecommunications sector and to encourage an expansion in broadband service. Having a diversified rival networks and operators with competing interests in place, prevents undue one sided pressure on regulators. Mechanisms for stakeholder participation in decision making and in the oversight of the regulatory process are in place, and a broad range of stakeholders take part in frequent consultations over policy and are knowledgeable and well organized and capable of making a forceful presentation of their viewpoints. In contrast, in a highly challenged (weak) setting, the regulatory process is typically captured by the monopoly incumbent (which may be either public or private) or by a cartel; the legal system is unable to defend the interests of the public, either by inefficiencies or corruption; hot topics are generally resolved in favor of the interests of the incumbent; and stakeholders are kept at bay from decision making and oversight.

Some developing countries approximate the ideal setting (e.g. Brasil, Chile) while others exhibit most of the conditions typical of a weak institutional environment depicted in Table 7 (Guyana). Most are situated somewhere in the middle between these extremes.

Effectiveness of Select Instruments

Reverse Subsidy Auctions

A reverse auction tender is an instrument of choice of Governments and donors to provide subsidies to encourage investment to develop rural broadband. It is also a very potent instrument. The design of a reverse auction tender should in principle be technology neutral, but in practice the way that a contest is designed may stack the odds in favor of one technology or another. This is especially true in thin telecom markets involving only a few bidders. This is why **they should be used sparingly in contexts in which the incumbent monopoly operator or cartel is powerful enough to either block the auction or capture the subsidies to strengthen legacy networks** (see Table 7).

Experience suggests the following considerations be weighted whenever donors and governments are planning a reverse subsidy auction.

R1 The regulator should have the independence and a track record of enforcing interconnection agreements prior to the planning stage of the subsidy auction. Otherwise it is best not to proceed with the contest.

R2 Network specifications should be consistent with demand requirements of low income, rural communities that have very little experience and few opportunities to make effective use of high speed broadband. Telephony, chat, email and videoconferencing are interactive technologies that are highly valued by users and should be assured by the tender, and that help enhance sustainability.

A suitable license and a competitively priced interconnection agreement should be part of the tender offer, to assure the winning enterprise that they will be able to complete local and international calls at affordable prices. The provision of VoIP connecting through the PSTN should be enabled prior to or conditional to the launching of the tender; as is the possibility that local operators are able to provide Wireless connectivity services on a commercial basis to the neighboring community. Aside from increasing impact of the connectivity provided, this will enhance sustainability.[9]

R3 Initial government sponsored investments should lay the groundwork for future expansion, and start by providing services that are commensurate with demand and the limited ability to pay of low income communities. Care should be taken to avoid spending more than is necessary on high throughput broadband. In particular, funding an infrastructure that will not be fully utilized for a long time to come and that could be swiftly overshadowed by new technology should be avoided. [10]

R4 Reverse subsidy auctions offer the opportunity to increase competition based on rivalrous infrastructure development. In a thin market, the structure of the tender gives very powerful signals that bidders read attentively. Structuring a tender into networks may help reduce risks and enable different operators with local knowledge to enter the market.

R5 Risks can be reduced by designing the tender in a way that combines connectivity to telecenters with connectivity requirements of government offices (Post Office, hospitals, police stations, libraries, secondary schools) in the small communities to be served.

R6 Given the magnitude of investments that have already been made using reverse subsidy auctions and their present popularity among donors, there has been remarkably little study of their impact and sustainability of benefits. This is a major research gap that needs to be addressed.

Effecting Change in Regulation

Effective regulation is more of an art form in politics and an exercise in leadership than a science (Jacint and Levi-Faur 2005, Jamieson 2005).[11] Donor projects can help support change, but the possibilities of success are limited to circumstantial opportunities in which the leadership and suitable political conditions for change exist. (IIa in Table 7).

Two issues presently deserving priority attention by regulators are: the liberalization of VoIP and its interconnection to the PSTN, and the liberalization of restrictions on spectrum to facilitate an expansion in the use of Wireless broadband technologies (IIb in Table 7; See also Purbo 2003).[12]

There are valid reasons to introduce some forms of regulation of VoIP, including the need to protect the public interest by ensuring that public safety numbers (e.g. 911 in the US) may be dialed by users of the new technology. But more often, however, questionable issues are also raised – mainly in the interest of incumbents - to justify regulation of Internet Telephony and restrictions on call termination to the PSTN. These include the need to collect taxes and to contribute to Universal Service Funds (Crandall *et al.* 2004). In practice, the revenues that could be collected at present from Internet telephony are minimal, and universal service funds are generally used in far less effective ways of achieving market penetration than competition between rivalrous networks.[13]

There are costs associated with the use of spectrum as a result of interference or related to the costs of setting up and managing its allocation. Modern Wireless technologies are very low cost to users, because the costs of setting up and to operate these networks are low and because congestion is substantially reduced through dynamic ways of allocating the spectrum (Lehr 2004). Whatever the merits of licensing spectrum in congested urban areas, these are hardly justified in the context of rural communities in developing countries.

R7 Donors and Governments committed to using ICTs to reduce rural poverty, would do well to focus on the liberalization of VoIP and VoIP interconnection to the PSTN and in the elimination of restrictions on the use of Wireless spectrum in the bands that enable WiFi and WiMax wireless networks (i.e. 2.4 and 5.8 Ghz bands).

Buildup Participation and Monitoring Capacity of Stakeholders

The Canadian regulator decided in favor of asymmetric deregulation of VoIP, largely in response to lobbying pressure from Canadian cable operators, Vonage, and other companies with a commercial stake on the success of VoIP (Carny 2005). In the US, ATT and MCI have been powerful supporters, among others (e.g. www.ipall.org), of the liberal treatment that the FCC has given to VoIP. In general, developing countries do not have similar forces to counter the pressure of incumbents on Government regulators; but Indonesia's recent experience with VoIP deregulation shows that individuals and organized grassroots groups can be effective agents of change.

Commendable donor efforts to increase developing country expertise and understanding of regulatory issues include international training events, conferences, and forums (e.g. www.regulateonline.org). But the mores and norms that determine political and regulatory behavior take shape in national contexts. This is why the buildup of national constituencies that can speak up in an informed and qualified fashion in the interest of consumers and of small operators is so important to increasing competition and effective regulation.

R8 Three kinds of interventions have the potential to contribute to such build up:

i. Training in wireless networking, including administration and management of sustainable networks.

ii. Local wireless network projects that increase competition at the edge, filling a gap in rural broadband service;

iii. Local Observatories of hot topics in telecommunications regulation, through which informed exchange, analysis and debate about regulatory issues takes place, and, whenever appropriate, incumbents, politicians and regulators are called to task. [14]

Concluding Remarks

If you ask Bona Simansuntak, Director of the Center for ICT Studies, Indonesia, what is going to happen after the 2 year period specified in the 2.4 GHZ deregulation decree expires, he will respond with confidence that after enjoying the benefits of Wireless the community will not allow Government to return to the old restrictive regime.

Bona may be underestimating the power of the incumbents to forestall competitive challenges. He may also be overly optimistic about the speed of deployment of valuable wireless networks in the next 2 years, particularly given the restriction on interconnection to the PSTN.

For the sake of broadband development in developing countries, we hope Bona is right.

Notes

1. Traditional media (fliers, newspapers, radio and television) are powerful means of disseminating information but have limitations as tools for personal interaction. The Internet and the telephone may be used to broadcast information but when used this way the richness of information and understanding that can be achieved through interactive exchange is lost. The Internet and the mobile phone are no substitute for face to face communications, but they can empower farmers and rural communities by enabling, expanding and strengthening networks and facilitating continuous low-cost human interaction. Reminiscent of the early development of snail mail and the telephone, social interaction through e-mail and chatting is often underestimated. Yet these interactions form the basis for socialization, the development of trust and economic integration.

> "Only a tiny fraction of the information passing through communications systems has ever been high quality scholarly knowledge. … sociability was frequently dismissed as idle gossip, and especially in the early days of the telephone, was actively discouraged. … a 1909 study of telephone service commissioned by the city of Chicago advocated measured rate service as a way to reduce 'useless calls'. Yet the most successful communication technologies, the mail and the telephone, reached their full potential only when they embraced sociability and those 'useless calls' as their goal. That seemingly idle chit-chat not only provided direct revenues, but it encouraged the diffusion of the corresponding technology, and made it more useful for commercial and other applications. Such social interaction frequently function to grease the wheels of commerce. [Odlyzko 2000, page 29].

2. According to Dodd (2005, page 12), ITU defines broadband as higher than 1.54 or 2 Mbps, the ability to carry full-motion video, and to support multiple streams of traffic. Here the term is used loosely to include technologies that may have smaller throughput but are nevertheless capable of providing advanced services – such as videoconferencing and VoIP. It is these low throughput technologies that are most suitable as a starting point service in rural areas.

Note also that these high value services can be delivered through low bandwidth connections thanks in part to parallel software compression innovations. This is the case of the 2,400 IIT-Madras sponsored kiosks highlighted in the text.

A technology like CorDECT has low throughput, but IIT Madras has developed low-bandwidth videoconferencing software that runs well in the available bandwidth. As Door (2003) notes, technologies that provide basic telephone services to rural population at low cost and some critical advanced IP services deserve consideration in comprehensive universal service plans of developing countries.

3. "Here is the punch line: initial trials have demonstrated that networks for voice and high-bandwidth data can be deployed over hundreds of kilometers, at costs currently under USD 50,000. Put another way, at per-subscriber costs approaching USD 30,015 (and continuing to drop), communities in relatively rural and dispersed areas can receive voice and data connectivity. Compare this to standard fiber and copper technologies deployed in many urban areas. There, network backbone costs can range from USD 20,000 to USD 40,000 per kilometer and, as a rule-of-thumb, per-subscriber costs hover at about USD 1000."

(Best 2003.)

4. Throughout the world in countries with low digital literacy the difference between adults who use ICTs and those who do not are striking. The following situations have been encountered by the author in the past 12 months:

- In Nicaragua, an on the spot survey (10 November 2004) of about 20 participants during a local training meeting of the Muy Muy UCODEL reveals that all of the participants were appreciative of the project sponsored telecenters (known as CIDELs) as an important agent of "progress and modernization"; yet only about 8 of them had actually used the CIDELs telephone services and none had used the Internet (although apparently some of their children had). All of the meeting participants lived farther than 2 km away from the CIDEL.

In Jequitinhonha, a poor and remote area of Minas Gerais, Brasil, three different instances were found in which computers and connectivity were installed in suitable premises (1 primary school, 1 center for disabled students, and 1 community center), the need to use the facilities was palpable, yet the equipment was not being used because no one nearby knew how to.

- A high ranking public official in Jakarta, manager of a nominal staff of over 30,000 people, does not use email, is not familiar with the Internet, and finds little use for computers or the Internet either for either personal or work related purposes.

- At a meeting of the Farmer Leader's Organization (the one sponsoring the primary school), representatives in attendance are asked if they have used the computer and the Internet. Their response: "Why ask such a silly question? We all use computers and the Internet for at least for 2 hours a day."

No verbal explanation or practical demonstration of the marvels of computers or the Internet can substitute for a neophyte user sitting down in front of a computer connected to the Net and working directly with it, developing proficiency and experiencing its practical usefulness through personal experience. Furthermore, the network effects of ICT use are powerful incentives for widespread adoption. If only a few friends and associates use the telephone, telephony is of limited value. It is when the network is large that it makes sense to use the telephone, the computer or the Internet. It is when many family and friends may be contacted through the phone or through email that people find a reason to learn how to use the technology.

5. A similar assessment appears in the 2003 and 2004 editions of the Office of the US Trade Representative Report.

6. "Technological advances in computer technology, fiber optics and wireless transmission have paved the way for competition in the local exchange. Regulatory policy tends to lag technical change because it protects current stakeholders against new interest groups. Current interest groups have large, well defined stakes and low costs of organization. In contrast, entrants tend to have ill-defined stakes (only options on future gains) and are heterogeneous, as are consumers who could benefit from entry. Thus regulation generally protects incumbents against entrants. Only after the entrants have established themselves can they gain influence similar to the incumbents. It is thus fortunate for the development of competition in the local exchange (and quite different from the earlier development of long-distance competition) that powerful incumbents in other markets, who are under the same regulatory jurisdiction as the ILECs (IXCs and cable TV companies), are among the most aggressive and potent entrants."

(Vogelsang and Woroch 1998, page 39.)

Unfortunately, in most developing countries there are no powerful competitors to challenge an incumbent's power to service rural areas.

7. For a review of the earlier reverse auction subsidies focused on rural telephony, see Wellenius 2002.

8. In a rapidly changing technology environment what is important is **dynamic sustainability**, a concept that goes beyond the immediate effects of an individual intervention or facility. In the case of commercial telecenters, i.e. cybercafes, not all are individually sustainable. Some fail while others thrive. Yet the system as a whole is resilient as long as there is a demand for the service. In a similar vein, all of the telecenters or services started by State Action **need not survive**. What is important is for these services to continue - provided by either the initial facility established through government or donor funding, or by other institutions, public or private, that arise subsequently to meet the increase in service demand stimulated by the initial program, or even by individuals who now use the technology through hand held or other low-cost devices.

9. "…the creation of interconnection, by itself, does not necessarily bring about competition, and can in fact lead to cartel cooperation that turns new entrants into complements rather than competitors (Mueller, 1988). Interconnection does not assure competition, but the lack of such interconnection has historically prevented its emergence. Interconnection has been a necessary but not a sufficient condition for competitive telecommunications." (Noam 2004, page 4).

10. Fiber is a more robust technology than VSAT and other wireless technologies, but there is no reason to believe *a priori* that fiber is a long term solution suitable for most rural areas. There is no clearly demarcated technological path to fiber, especially considering presently low levels of broadband demand in rural communities. VSAT and the new wireless technologies coming on board, particularly WiFi and WiMax, by not requiring extensive cabling are more flexible and scalable and thus more suitable to the present uncertain rural demand environment.

> "the network evolution path does typically not lead in a linear way from one dominant network technology to a predefined successor technology, e.g. from copper to fiber, without significant intermediate innovations. Rather, technological rivalry along the technological trajectory can fundamentally alter the path. For example, facility competition between (fixed) wireless and wire line technologies might lead to a variety of hybrid broadband access solutions with no single transmission medium (e.g. fiber) achieving universal deployment in the long run."
>
> (Kiessling and Blondeel 1999, page 4.)

11. The literature on regulatory framework design is extensive. See for instance Noll 1999, Eustache and Mortimort 1999, Srivasttava 2002, Konvitz 2004.

12. "Marketplace experience suggests that expensive networks most likely develop not from 'opening' existing delivery platforms to multiple operators, but from policies nurturing the development of rival infrastructure in adjacent markets or the adoption of alternative technologies. Foremost among these are policies to encourage investment in broadband and wireless telecommunications networks."

(Hazlett 2005, Executive Summary).

13. It is not uncommon for Universal Service Funds to be promoted and structured with significant input from incumbent operators, as a means of adding barriers to potential new entrants into telecom markets.

14. "The trick to getting rid of inefficient regulation is making these costs sufficiently visible to force politicians and regulators to pay attention to them." (Crandall *et al.* 2005).

Works Cited

Adythia, Raghunathan, "The Economic Advantage of Wireless Infrastructure for Development", Sustainable Development Department, Technical Papers Series, April 2005. (www.iadb.org/sds/publication/publication_4105_e.htm)

Aizu, Izumi, "A Comparative Study of Boadband in Asia: Deployment and Policy", September 29, 2002. (http://www.anr.org/web/html/index_e.htm).

Apoyo, Uso y Actitudes hacia Internet, 2005.

Autorité de Régulation des Télécommunications (ART), The Telecommunicaions Market in France 1st Quarter 2003 (Licensed Operators), September 2003. (www.art-telecom.fr/observatoire/stat/1-2003/statrim1-03-gb.htm)

Beale, Brian, "Market Opportunities for Wholesale and Retail VoIP in the Developing World: A Bolivian Case Study", November 2004. (http://voip.cict.dtu.dk/presentations/Brian_Reale.pdf)

Best, Michael, "The Wíreles Revolution and Universal Access", Chapter 7 in Trends in Telecommunications Reform, 2003. (http://itc.mit.edu/itel/docs/2003/michael_best.pdf)

Charny, Ben, "Canada Regulation Free for VoIP Startups", CNet, 12 May 2005. (http://news.com.com/Canada+regulation-free+for+VoIP+startups/2100-1037_3-5705216.html)

Clarke, Nathaniel B., "Internet Telephony in Indonesia with Recommendations on Policy", Technical Report of Partnership for Economic Growth (PEG) Project, November 2002. (www.pegasus.or.id/Reports/106)%20Internet%20Telephony.pdf)

Coloma, Fernando, and Tarziján, Jorge, Regulación: Objetivos, Problemas y Opciones que se abren en el Mercado de la Telefonía Fija Local, Documento de Trabajo No. 232, December 2002. (www.economia.puc.cl)

CONATEL, "Resolución -073-02-CONATEL-2005", 25 January 2005. (www.conatel.gov.ec/descargas/formatopdf/resolucion73-02-2005.pdf)

Crandall, Robert W., Robert W. Hahn, Robert E. Litan, and Scot Wallsten, "Internet Telephones: Hangin up on Regulation?", AEI-Brookings Joint Center for Regulatory Studies, Regulatory Analysis 03-12, Publsihed in the Millken Institute Review, 2004. (www.aei-brookings.org/admin/authorspdfs/page.php?id-316)

Dodd, Anabel Z, The Essential Guide to Telecommunications, Fourth Edition, 2005.

Door, Roberto, "Technologies for Universal Access", Extract from the chapter "La Obligación del Servicio Universal" by Roberto C.Door (pages 219/260, "La sociedad de la Información", UPC, 2003)

Eustache, Antonio and Martimort, David, "Policies, Transaction costs and the Design of Regulatory Institutions," WPS No. 2073, 1999. (www.worldbank.org/wbi/governance/pubs/wps2073.html)

Galperin, Herán, "Wireless Networks and Rural Development: Opportunities for Latin America", December 2004. (www-rcf.usc.edu/~hernang/lasa04paper.pdf)

Gobierno de Chile, "Campaña Nacional de Alfabetización Digital", 2004 (www.alfabetizaciondigital.cl).

Hazlett, Thomas W., "Rivalrous Telecommunications Networks With or Without Mandatory Sharing", AEI-Brookings Joint Center for Regulatory Studies, Working Paper 05-07, March 2005. (www.aei-brookings.org/admin/authorpdfs/page.php?id=1134)

Horst, Heather and Miller, Daniel, "The Cell Phone: An Anthropology of Communication", June 2005. (www.dgroups.org/groups/icacaribbean/index.cfm?op-dsp_resource_details&resource_id=18659&cat_id=745)

Horvitz, Robert, "Influence of Liberalization of IP Telephony on the Telecommunications Market in Bosnia and Herzegovinia", 2002. (www.internetpolicy.net/telco/cra.pdf)

Intelecon, Universal Access and Universal Access Funds: Insights and Experience of International Best Practice, July 2005. (www.inteleconresearch.com/pdf/050713%20-%20universal%20access%20and%20universal%20service%20funds%20v3.pdf)

Inter-American Development Bank, Tecnologías de Información y Comunicación al Servicio de la Competitividad y la Integración Sudamericana, Iniciativa de Integración de la Infraestructura Regional en América del Sur (IIRSA), December 2003. (www.e-paratodos.org/pdf/IIRSASA0204s4.pdf)

International Telecommunications Union, Broadband Korea: Internet Case Study, March 2003. (www.itu.int/ITU-D/ict/cs/korea/material/CS_KOR.pdf)

International Telecommunications Union, Shaping the Future Mobile Information Society: The Case of the Republic of Korea, February 2004. (www.itu.int/osg/spu/ni/futuremobile/general/casestudies/koreacase-rv4.pdf)

Jensen, Mike, "Interconnection Costs", September 2005. (http://rights.apc.org/papers.shtml)

Jordana, Jacint and Levi-Faur, David, The Politics of Regulation, 2004.

Jamieson, Mark A., Leadership and the Independent Regulator, World Bank Research Working Paper No. 3620, June 2005. (http://bear.cba.ufl.edu/centers/purc/documents/LeadershipandtheIndependentRegulator0605.pdf)

Kiessling, Thomas and Blondeel, Yves, "The impact of regulation on facility-based competition in telecommunications: a comparative analysis of recent developments in North America and the European Union", March 1999. (www.tik.ee.ethz.ch/~m3i/related-work/cm/Cost-Regulation-in-Telecoms-Kiess_Mar99.pdf)

Konvitz, Josef, The Institutional Context for Better Regulation, October 2004. (www.justitie.nl/english/Images/josef_konvitz_071004_tcm75-28692.pdf)

Lee, Nae-Chan, "Broadband Internet Service: Korea's Experience", February 2002. (www.mic.go.kr/eng/res/res_pub_db/res_pub_sep_brd/Broadband_Internet_in_Korea_2002.pdf)

Lee, Heejin, and Choudrie, Jyoti, "Investigating Broadband Deployment in South Korea: Broadband Mission to South Korea", DTI/Brunei University, October 2002. (www.broadbanduk.org/reports/SKorea_report.pdf)

Lehr, William, "Economic Case for Dedicated Unlicensed Spectrum Below 3 GHz", 17 May 2004. (http://itc.mit.edu/itel/docs/2004wlehr_unlicensed_doc.pdf)

Mahan, A. K., and Melody, W. H., Stimulating Investment in Network Development: Role for Regulators, World Dialogue on Regulation for Network Development, June 2005. (www.regulateonline.org/content/view/435/31/)

Minister of Communications, "Regulation of the Minister of Communications Number KM.2 Year 2005 on Use of 2400-2483.5 Mhz Frequency Bands", Indonesia, 6 January 2005.

Moulton, Peter, and Moulton, Jason, The Telecommunications Survival Guide, Prentice Hall, 2001.

Neto, Isabel, Best, Michael, and Gillet, Sharon E., "License-Exempt Wireless Policy: Results of an African Survey", 2004. (www.inta.gatech.edu/michael_best/wireless.pdf)

Nieminen, Klaus, VoIP Regulation, Helsinki University of Technology, 16 November 2004. (www.netlab.hut.fi/opetus/s38042/s04/Presentations/17112004_Nieminen/Nieminen_paper.pdf)

Noam, Eli, "Interconnection Policy", 2004. (www.citi.columbia.edu/elinoam/articles/intercon.htm)

Noll, Roger, G., Telecommunications Reform in Developing Countries, AEI-Brookings Joint Center for Regulatory Reform, Working Paper 99-10, November 1999. (www.aei-brookings.org/admin/authorpdfs/page.php?id=200)

Park, Han Woo, "The Korea Information Society and Mass Media", 2001.

Priowirjanto, Gatot Hari, "ICT Development in Indonesian TVET", Power Point Presentation (undated, circa 2005).

Proenza, Francisco, Telecenter Sustainability: Myths and Opportunities, Journal of Development Communication, December 2001. (www.e-forall.org/pdf/TelecenterSustainability.pdf)

Proenza, Francisco, "Information and Communications Technologies at the Service of the Rural Poor in Latin America and the Caribbean", Investment Centre, July 2005.

Purbo, Onno, "A Plea to ICT Regulator", July 2003. (www.apjii.or.id/onno/some-aticles/a-plea-to-ict-regulaor-7-2003.txt)

Purbo, Onno, "Self-Finance Sustainable ICT for Development: Strengthening the Grassroots", 2004. (http://sandbox.bellanet.org/~onno/the-guide/alt-ict-route/)

Reynolds, Taylor, and Samuels, Ayanna, Building Digital Bridges with Emerging Technologies, ITU Background Paper for Korea Symposium on Building Digital Bridges, August 2004. (www.itu.int/digitalbridges)

Robitaille, Nadine, "Man on a Mission: Researcher Profile, Dr. Onno Purbo", 17 November 2003. (www.idrc.ca/en/ev-45872-201-1-DO+TOPIC.htm).

Roes Setiyadi, Wigrantoro, "Promoting Internet Policy and Regulatory Reform in Indonesia: Status of Information and Communication Technology Development in Indonesia", The European Union's Asia IT&C Programme for Indonesia, Assessment Report, February 2003. (www.internetpolicy.net/about/indonesia-assessment.pdf)

Samarajiva, Rohan, and Dokeniya, Anupama, Regulation and Investment Sri Lanka Case Study, with annex by Sabina Fernando, Shan Manikkalingam and Amal Sanderatne, Discussion Paper WDR 0303, September 2004. (www.regulateonline.org/content/view/207/31/)

Srivastava, Leena, Issues in Institutional Design of Regulatory Agencies, December 2000. (www.teriin.org/division/regdiv/docs/ft23.pdf)

Staebroek News, "President Accuses GT&T of bad faith, blackmail over IDB loan", June 19, 2002a.

Staebroek News, "Prior's lobby against IDB IT loan astounding – PM", June 21, 2002b.

Staebroek News, "Did ATN Miscalculate?", Editorial, 23 January 2004. (www.stabroeknews.com/index.pl/article?id=2648465)

Staebroek News, "Telecoms reform a no-go –info tech project sheled, technical co-op pact halted", Sunday, October 2, 2005. (http://www.stabroeknews.com/index.pl/article?id=31031247).

Sulaiman, Idris F. "Impending Growth of Indonesia's Market for ICTs and its Regulatory Constraints, Paper prepared for Economic Growth (PEG) Project August 2003. (www.pegasus.or.id/Reports/141)%20Indonesia's%20ICT%20Market.pdf)

Office of the United States Trade Representative, "Sri Lanka", 2005 National Trade Estimate Report on Foreign Trade Barriers. (www.ustr.gov/Document_Library/Reports_Publications/2005/2005_NTE_Report/Section_Index.html)

Tcha, Dong-Wan, June S. Park, Suk-Gwon Chang, and Kwan Ho Song, "Korean telecommunication industry in transition", July 1999. (www.digital.re.kr/changsg/_private/changsg02.PDF)

Vinueza Morejón, Bibiana, and Rodríguez Ríos, Verónica, Los Cibercafés en la Ciudad de Quito. Thesis, Universidad Central del Ecuador. (http://unesco.org.ec/cibercafesquito/)

Vogelsang, Ingo, and Woroch, Glenn, "Local Telephone Service: A Complex Dance of Technology, Regulation and Competition", 1998. (http://elsa.berkeley.edu/~woroch/dance.pdf)

Wellenius, Björn, Closing the Gap in Access to Rural Communications: Chile 1995-2002, World Bank Discussion Paper No. 430, February 2002. (http://rru.worldbank.org/Documents/PapersLinks/1222.pdf)

White, Matthew, "Onno Purbo: Man with a Mission: Tech rebel is…Supurbo!", Acacia Web Times, 2003. (www.acacia.org.za/WEBTIMES/wednesday.htm)

WiMax-UK, Americatel Peru to Build WiMAX-Ready Network in Latin America Using Alvarion's BreezeMAX(TM), 9 August 2005. (www.wimax.co.uk/PR2005/FEB2005/2383.htm)

World Bank, Project Appraisal Document on a Proposed Credit in the amount of SDR 36.3 million (US$53.0 million equivalent) to the Democratic Socialist Republic of Sri Lanka for an e-SriLanka Development Project", Report No. 28979-LK, 24 August 2004. (www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/09/10/000009486_20040910112659/Rendered/PDF/28979a.pdf)

World Bank, Indonesia: Information and Communication Technologies for Rural Development: Issues and Options, Report No. 33503-ID, October 2005. (www.e-forall.org/pdf/ICT4RD_October2005.pdf)

Yun, Kyounglim, Lee, Heejin, and Lim, So-Hye, "The Growth of Broadband Internet Connections in South Korea: Contributing Factors", Asia-Pacific Research Center, Stanford Institute for International Studies,September 2002. (http://aparc.stanford.edu/publications/20032/)