Research Article

# The Road to Broadband Development in Developing Countries Is through Competition Driven by Wireless and Internet Telephony

**Francisco J. Proenza**
francisco.proenza@fao.org
FAO Investment Centre
Food and Agriculture
Organization of the
United Nations
Viale delle Terme di Caracalla
00100 Rome
Italy

## *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 options, wireless technologies are making it easier for new competitors to 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 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, lack independence, and often are 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 requires large investments that have not been forthcoming from the private sector. There have been few new entrants, because of the low potential profits, as well as the high risks and obstacles associated with penetrating a weakly regulated market dominated by a monopoly.

This article 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 rival networks to increase investment in telecommunications, iden-

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tifies regulatory and governance obstacles that must be overcome, and outlines some strategic considerations for crafting donor and government interventions.

## Significance of VoIP and Wireless for Low-Income People

### *VoIP*

VoIP is invaluable to low-income users. 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 ISPs and *cabina* operators have led to low service costs (e.g. less than US$ 0.50 for an hour of computer/Internet use in Lima [May–June 2004; Apoyo 2004]). Most of Lima's Internet users—88% of users aged 8–70—connect to the Internet through *cabinas.* But, whereas *cabina* use is a matter of convenience for high-income customers, for low-income people they often represent the only access option. Ninety-three percent of low-income users use *cabinas* as their habitual place to connect to the Internet, compared to 22% for high-income users. VoIP is used broadly by all income class users of *cabinas,* but incidence of use is higher among low-income users (40%) than for all users (33%).

VoIP is also a major source of income for Nicaragua's 700 cybercafés. For the 10 rural telecenters sponsored by the World Bank, VoIP is critical to achieving sustainability, generating about 30% of total service revenues (Proenza 2005).

Cybercafés are commonplace in Ecuador's cities and large towns. In Quito, the main purpose for using cybercafés is communications, with nearly 50% of users indicating that keeping contact with family and friends is their main objective. VoIP is an important service used by 17.5% of users surveyed (Vinueza and Ríos 2004).

In Indonesia, a pilot project sponsored by the 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 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 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.* They are going to play an increasingly prominent role in the expansion of rural telecommunications networks in developing countries (Galperin 2004; Reynolds and Samuels 2004).

#### Bandwidth Requirements of Low-Income Rural Communities

According to Dodd (2005, 12), ITU defines broadband as higher than 1.54 or 2 Mbps, the ability to carry full-motion video and 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.

Rural demand is best met gradually, beginning with low bandwidth sufficient to provide the basic communications services that people value (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. Acknowledging the limited rural demand for bandwidth, 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 1).

High-value services can be delivered through low-bandwidth connections thanks in part to software compression innovations. In the case of n-logue kiosks, videoconferencing software developed also by IIT-Madras is specifically designed for and runs with the low bandwidth provided through corDECT.

#### Cost, Scalability, and Ability to Serve Diverse Populations at Low Cost

Telecommunications networks are underdeveloped in rural areas that are difficult to serve because 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. Wireless networks are easy to deploy, easy to

*Table 1. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean*

| Country and date of tender | No. of points of service | No. of computers/center | Connection speed/technology | Status |
|---|---|---|---|---|
| Chile:<br>Population 18.7 million<br>GDP/cap (US$ppp)= 8652<br>Literacy rate= 91.4<br>HDI rank 81 (index= .735) | 253 telecenters in 35 clusters | At least 4 computers (at least 1 with CD burner) | Minimum speed 128 Kbps between tele-center and ISP (both ways); plus 32 Kbps for each additional computer installed.<br>209 centers awarded: 65% wired technologies (dial up, ADSL, ISDN and dedicated line); 35% wireless (mostly VSAT but also GPRS and WLL) | This is Chile's 2nd tele-center program; presently under execution. |
| | Rural schools connectivity, 2004<br>667 Rural Elementary Mid-level Schools serving 108,646 children,<br>Participating schools have to enable service to the community | Number of PCs/school (1–36) depends on school size (10–1000 children). | Small schools: (64 / 32 Kbps).<br>Large: (256 / 128 Kbps).<br>Free service to schools for three years.<br>Subsidy of US$ 6,650,000 awarded to two 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 ($61) is similar for both companies. | Tender awarded end of 2004. Project under execution. |
| Brazil (2003–2004):<br>Population 174.1 million<br>GDP/cap (US$ ppp)=7360<br>Literacy rate = 87.3%<br>HDI rank 75 (index= .777) | 3,200 telecenters | Average of 5 computers/center. | Broadband 256 Kbps service using VSAT.<br>Free of charge to users and local operators over 22 month service period. | Project under execution 2003–2005. |
| Peru, September 2003:<br>Population 25.2 million<br>GDP/cap (US$ppp)= 4622<br>Literacy rate= 89.6<br>HDI rank 73 (index= .743) | District capitals, first phase (2005)<br>68 district capitals | 68 access points, each with 3 data ports, one to serve a local telecenter (equipped with at least one PC). | Each district capital served by 3 ethernet 10/100 Base T ports with Internet access (IP Protocol). Minimum speed per port will be 128 Kbps, with maximum asymmetry of 4 : 1 (uplink speed to downlink speed). The winning consortium will use VSAT technology.<br>Subsidy award = approx. US$ 1,000,000. | Tender announced in February 2, 2005, and awarded July 25, 2005. Service contract is for four years. |

*Table 1. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean (continued)*

| Country and date of tender | No. of points of service | No. of computers/center | Connection speed/technology | Status |
|---|---|---|---|---|
| Colombia COMPARTEL:<br>Population 41.4 million<br>GDP/cap (US$ppp)= 5749<br>Literacy rate= 95.3<br>HDI rank 62 (index= .765) | First tender public telephony and internet access points<br>6,745 public telephones in small towns with less than 250 people<br>670 Internet centers | Each telecenter equipped with one computer and one printer. | Minimum navigation speed: 1 Kbps.<br>User price fixed at US$ 1/hour.<br>Estimated subsidy per Telecenter US$ 9,230<br>Winning bidder was Gilat using 70% VSAT and 30% cellular technology. | Awarded in March 2000. Operation and maintenance contract is for 10 years. |
| | Second tender—social internet<br>261 telecenters contracted, but 285 were installed by operator at own cost. | Three computers in cities with < 30,000<br>Six in cities with 30,000 to 200,000<br>12 in cities with over 200,000<br>Subsidy award: US$ 29,000/center | Minimum effective navigation speed/pc: 4 Kbps.<br>User price fixed at US$ 1/hour.<br>Subsidy: US$ 28,900/center.<br>Awarded to land line incumbent who will use VSATs (Hughes) for these centers. | Under execution by Moreno S.A.–Telefonica Data. since mid 2001.<br>Five-year contract ends October 2006 |
| | Third tender—telecenters<br>500 telecenters in small towns:<br>30% > 2,000 people;<br>56% with 2,000–5000 people;<br>13% with 5,000 to 10,000. | Two, four, or six public telephones in each telecenter and up to three public phones located in public institutions (mayor, police station, hospital, health clinic)<br>eight computers per center (one for administration)<br>training room for 20 people 1 training of users & variety of services | Minimum effective navigation speed per PC 7 Kbps;<br>Contract was awarded to sole bidder, Gilat (VSAT manufacturer).<br>Subsidy award: US$ 80,000/center (including public telephone service, training, etc.) | Under implementation since 2003.<br>Service contract is for six years. |

*Table 1. Selected Features of Recent Rural ICT Development Least Cost Subsidy Auctions in Latin America and the Caribbean (continued)*

| Country and date of tender | No. of points of service | No. of computers/center | Connection speed/technology | Status |
|---|---|---|---|---|
| Columbia, cont. | Fourth tender<br>Broadband for public agencies—first phase<br>3,000 schools,<br>624 local gov.,<br>120 hospitals and<br>30 military garrisons. | 1,372 with 3–4 computers (128/48 Kbps)<br>592 with 5–8 computers (128/64 Kbps)<br>691 with 9–12 computers (256/96 Kbps)<br>1,119 with 13–16 comp. (256/128 Kbps) | First phase tender awarded to<br>North: COMSAT Int.—Inalambrica<br>South: Internet por Colombia<br>VSAT Technology;<br>Subsidy: US$ 11,620/public agency. | First phase tender issued March 2004;<br>Awarded 2004.<br>Service Contract is for six years. |
| | Fifth tender<br>Broadband for public agencies—second phase<br>3,793 schools<br>427 municipalities<br>80 health centers<br>57 Agroentrepreneurial centers | 2,820 with 3–4 computers (128/32 Kbps)<br>241 with 5–10 computers (128/32 Kbps)<br>476 with 11–15 computers (256/64 Kbps)<br>740 with 16–20 computers (256/64 Kbps)<br>80 with 1–4 computers (512/256)—health posts | Second phase tender awarded to:<br>North: COMSAT-Inalambrica Internet<br>VSAT & Fixed wireless (Airspan)<br>South: e-America S.A. VSAT Technology | Second tender awarded Nov. 2005.<br>72 month contract<br>Execution started early 2006. |

*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).*

upgrade to accommodate increases in demand requirements and they require relatively small investments.[1] (Best 2003; Adythia 2005)

**Local Networks 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 (2006) 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. In 2004, for example, local calls accounted for 57% of the minutes and 32% of the revenues of France's fixed-line telephone market, compared to 32% of the minutes and 32% of the revenues for long-distance (national and international) calls (Autorité de Régulation des Télécommunications 2005).[2]

Where the terrain supports relatively low cost of deployment of mobile base stations (e.g. in island countries like Jamaica and Sri Lanka) commercial mobile telephone service has penetrated rural areas rapidly. Unlike computers, new skills are not required in order to use a mobile phone, and mobile telephony's cellular form of deployment facilitates local communications. Mobile phones thus reinforce local communication networks and demand for them rises fast.

By contrast, government-sponsored attempts to extend 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 the establishment of one public telephone or a telecenter in each small town. These facilities provide valuable services, particularly for communities with significant migrant populations, but at best meet only a part of the communication needs of rural people and constrain the potential profits attainable from private service provision.

ITU's telecenters in Honduras have been using wireless solutions since 2000 to address directly 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 ISPs for neighboring residents and data at a lower rate (using spread spectrum and radio packets) to low-cost and low-maintenance single-computer minicenters located in neighboring villages. Soon after it was instituted, this ISP service became a major source of revenue for these telecenters, helping to cover costs for the mother center while keeping the cost of servicing satellite minicenters affordable (ITU 2004).

The widespread adoption of a standard, such as WiFi or WiMax, will significantly lower the cost of 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.

### *The Emergent Rural Service Model*

In the late 1800s and early 1900s, the United States relied on a large number of small cooperatives and microtelcos (Owen 1998). The picture changed, in the United States and elsewhere, as technology, economics, and politics weighed in favor of large infrastructural investments and a standardized wire line network with access controlled by a monopoly operator.

Recent advances in technology have taken a different turn. Mobile wireless telephony challenged the dominance of wire lines in urban markets, but the investments required are large and access to the network remains under the control of the operator.

A "new" business model is emerging (Hammond and Paul 2006; Owen 2006). It allows small operators to serve rural communities at low cost and provide a more valuable service by enabling rural communities to connect with distant associates and nearby neighbors. It profits from VoIP's ability to

*1. "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.)*

*2. Data are for fourth quarter 2003 through third quarter 2004. The remaining calls from fixed lines, representing 11% volume and 37% value, were to mobile phones.*

unbundle the local loop (Melody, Sutherland, and Tadayoni 2005): networks already in place become transport pipes, available for anyone to use and connect to. For last-mile service it relies on WiFi or, increasingly, the fixed wireless technologies (e.g., WiMax); for backhaul on VSAT or on a link to the wire-line network.

Unfortunately, many of the companies and IP networks being established to satisfy developing country demand are considered illegal (Gordon 2004). For the promise of the new technologies to be realized, important regulatory constraints will need to be overcome.

## The Regulatory Challenge

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

### *VoIP*

Some countries see VoIP as an innovative technology that increases competition and a way to lower costs and increase consumer surplus. The United States 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).[3] The situation is quite different in developing countries, where restrictions on VoIP frustrate the development of IP-based networks.

Table 2 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 worldwide. SkypeOut rates are for VoIP service from PC to PSTN telephones and are largely determined by interconnection charges of incumbent national operators (Dodd 2005, 179). They are influenced by regulatory policies and the ability of incumbents to capture monopoly rents.

The base SkypeOut rate is for international calls to the United Kingdom, the United States, and Canada, and is US$ 0.021/minute. Calls to developing countries with an open regime (e.g., Chile) also achieve this low rate. Countries with vigorous competition such as Korea also achieve low rates (US$ 0.025/minute).

The 13 countries with the highest SkypeOut rate (i.e., those ranked 7–18) may be characterized by weak regulation or by purposeful government protection 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 1700%. Guyana's monopoly carrier does not allow VoIP calls through cybercafés using their services. Guyanese ISPs using wireless technologies are competing and providing VoIP services but are challenged by the regulator.

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

### *Wireless*

Information is sparse with respect to regulations on

*3. The dispute in Canada is ongoing, with incumbents using their political clout to try to circumvent the regulator (Janisch 2006). Also, it is not clear that the Canadian regulator's stance is the most appropriate one, given the avowed objective of encouraging facilities based competition. Boyer and Mercier (2005) suggest that the regulator could better support the development of VoIP through, for example, lump-sum subsidization of new entrants.*

*4. The fight over VoIP can be fierce. In Indonesia, in 2001, the government arrested the directors and confiscated the equipment of many ISPs who were providing unlicensed VoIP service (Sulaiman 2003, 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).*

*Table 2. SkypeOut Rates and VoIP Related Regulation in 22 Countries*

| | Skype-SkypeOut Rate[a] (US$/Min) | | | |
|---|---|---|---|---|
| **Region / Country** | **US$/min.** | **As % of US-UK Rate** | **Rank** | **Notes on VoIP and Related Regulation[b]** |
| 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 (Reale 2004; Nieminen 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 (CONATEL 2005). |
| 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 is 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 2. SkypeOut Rates and VoIP Related Regulation in 22 Countries (continued)*

| Region / Country | Skype-SkypeOut Rate[a] (US$/Min) US$/min. | As % of US-UK Rate | Rank | Notes on VoIP and Related Regulation[b] |
|---|---|---|---|---|
| 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 September 2004, there were seven 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. |

[a] *SkypeOut Rates are those effective August 8, 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.*

[b] *VoIP Regulation information for Argentina, Brazil, Chile, Colombia, Mexico, Peru, Venezuela, India, U.S., and U.K. is from the Global IP Alliance, www.ipall.org/matrix/. Information for the other countries considered has been gathered by the author.*

the use of bands that in the United States and Europe are license-free and that are fundamental to widespread deployment of Wireless technologies like WiFi and WiMax. Neto, Best and Gillet (2004), for Africa, and Galperin (2004), for South America, find highly restrictive regulatory requirements for use of the key spectrum bands that are commonly considered license-free in OECD countries. Beyond licensing, traditional operators servicing a sizeable network will reject interconnection or extract high fees for access to its customers by rivalrous wireless *networks,* 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 the 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 other countries with strong regulators where the state has no stake in the dominant carriers (e.g., Chile, Brazil, Perú). Sri Lanka's govern-

ment direct interest in the economic well-being of the incumbent operator has the potential to compromise the independence of 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 more blunt in their assessment.[5]

The incumbent's 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 first open bid to provide connectivity to the centers was won by a VSAT operator, but the cost of interconnection to the PSTN achieved was high. As a result, the cost of local calls in the project-sponsored telecenters (about 80 in mid 2005) were too high and revenues from telephony were 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 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

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, to identify 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 followed in other countries. About 43% of Korean households are connected to an average of 4 Mbps (ITU 2003), and pay only about US$ 50/month (ITU 2004). South Korea's extensive broadband deployment is mainly reliant on wire-line networks serving a predominantly urban population (80%). About 90% of Korean households have access to broadband through ADSL and 57% through cable mo-

*5. According to the 2005 report of the Office of the U.S. Trade Representative (p. 581):*

> *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.*

*Similar assessments were made in the 2003 and 2004 U.S. Trade Representative Reports.*

*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, 39).*

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

dem. Apartment LANs and wireless technologies cover 9%.

South Korea's experience, with the state playing a key role and emphasis on stimulating the development of rivalrous networks and on the buildup of demand through ICT literacy training, deservedly serves as an inspiration for developing countries (Aizu 2002). It is nevertheless an urban model developed in a high-income country and these features limit its applicability to infrastructure development in rural low-income environments. High density helps spread investment costs of wired deployment among many customers and a high income enables the market to bear higher costs of broadband deployment.

### *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 1 presents a summary of some recent auctions in South America. Several involve the establishment of telecenters. Others provide broadband and telephony to communities, schools and public agencies.[7]

These contests are regarded to be a transparent, market-driven approach that facilitates fiscal discipline (IADB 2003). Another feature, one often overlooked, is that reverse auctions can foster competition by enabling new entrants to 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.

#### High Risks, Thin Markets

In light of the specialized and complex expertise involved, the magnitude of investments, and the uncertainties associated with serving a new low-income market, risks are high, and 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 second tender; the majority of networks served under Chile's second infocenter tender) or for no bidder to show up.

#### Technology Neutral Contests Favor Wireless for Rural Areas

All of the South American contests have pursued "technological neutrality." Nevertheless, a clear pattern emerges favoring wireless. The dominance of VSAT has been decisive, but also some of the newer technologies—WiFi, fixed Wireless—are beginning to show up as winners.

VSAT was the choice technology in eight of the nine contests listed in Table 1. This is at odds with a common misperception of VSAT as an expensive technology and underscores the significance of local requirements. VSAT is expensive relative to wired options in urban settings, but it is an economically viable option to serve rural communities sparsely settled in rugged terrain. Further, VSAT enables new entrants to bypass wire-line networks, except as needed to interconnect with the PSTN.

#### Incumbents Do Not Like Reverse-Subsidy Auctions

Legacy operators see transparent competitive reverse-subsidy auctions as a competitive threat that can 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 (IADB) 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. The incumbent monopolist mounted a persistent challenge, including through U.S. courts to prevail on the U.S. Treasury and the IADB to stop the loan. Although a U.S. court judge overturned the case, both projects were cancelled. (Ramotar 2002; Singh 2002; Stabroek News 2002, 2005).

The e-Sri Lanka project approved in 2004 provides for the establishment of two regional telecommunications networks (RTNs)—one to bring broadband service to the north of the country and the other one to serve the deep south—both to be funded with government support through a reverse subsidy auction. Implementation of the RTN compo-

*7. See Wellenius (2002) for a review of the earlier reverse auction subsidies focused on rural telephony.*

nent is being challenged in court by a group of license operators that includes the incumbent.

### *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/) are dedicated to bringing ICT services to all of India's villages. The principal technologies developed include wireless corDECT technology, which functions as a telephone exchange; and various applications requiring limited bandwidth.

One of the enterprises launched by the Tenet group, n-logue Communications (www.n-logue.com/), 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. To achieve sustainability, each kiosk only needs to earn an average of about US$ 90/month, a low value achievable in India thanks to a combination of corDECT wireless technology and the country's extensive optical fiber network used as backhaul.

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

Chiraag kiosks derive an important part of their income from interactive services such as e-mail, videomail, and videoconferencing, in lieu of local telephony which they are not legally allowed to provide.

#### Indonesia's WiFi Networks

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. With support from Indonesia's Ministry of National Education, the center has also been training vocational school teachers, to help them set up and manage their own school-based WiFi Networks (Priowirjanto 2005).

The Center for ICT Studies began operations on the legal fringe in Indonesia. Vigorous lobbying by the project's promoters—individuals within the Ministry of Education and private technology activists (Robitaille 2003; White 2003; Purbo 2004)—have led to the liberalization of the 2.4–2.483-Ghz band on January 6, 2005 (Minister of Communications 2005). 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, policymakers, entrepreneurs, and social activists will rely on a variety of instruments, which may be grouped into four broad categories:

1. *Subsidies to stimulate investment* to serve unprofitable (mostly rural) areas.
2. *Institutional strengthening* to help countries introduce *major* changes in their overall regulatory and legal framework.
3. *Focused support* to help regulators address specific critical issues, such as the liberalization of VoIP and liberalization or allocation of key spectrum bands.
4. *Buildup of stakeholder capacity* to broaden effective lobbying and increase competition at the edge.

The effectiveness of these instruments depends on the regulatory setting. If the wrong instruments are used, at best a waste of valuable resources will occur, at worst considerable damage will be done by thwarting competition and enhancing the value of

the wireline network and hence the power of an incumbent monopolist.

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 help 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 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 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., Brazil, Chile) while others exhibit most of the conditions typical of a weak institutional environment (Guyana). Most are somewhere in between.

## *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 should 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.

Experience suggests the following recommendations be considered when planning a reverse subsidy auction.

1. 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.
2. Reverse subsidy auctions offer the opportunity to expand rural service and simultaneously also increase competition based on rivalrous infrastructure development. Ways to do this include
   A. Interactive services—telephony, chat, email and videoconferencing—should be assured by the tender.
   B. A suitable license and a competitively priced interconnection agreement should be part of the tender offer, to ensure that the winning enterprise will be able to complete local and international calls at affordable prices. VoIP interconnection through the PSTN should be secured prior to or conditional to the launching of the tender,[8] as is the possibility that local operators are able to provide wireless connectivity services on a commercial basis to the neighboring community.
   C. Network specifications should be consistent with low bandwidth requirements of rural communities. Funding an infrastructure that

*8. "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, 4).*
*9. There is no reason to believe a priori that fiber is a long-term solution for rural areas. 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 compe-*

will not be fully utilized for a long time and that could be swiftly overshadowed by new technology should be avoided.[9]

D. Partitioning the area to be served within a tender, so that bidders may apply to serve small clusters (networks), may help reduce risks, and enable different small operators with local knowledge to enter the market.

3. 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 post implementation impact and sustainability of benefits. This is a major research gap to be addressed. Future research should include a review of the impact of these contests on competition policy.

**Effecting Change in Regulation**

Effective regulation is more of an art form in politics and an exercise in leadership than a science (Jordana and Levi-Faur 2004; Jamieson 2005).[10] Donors 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.

Two issues presently deserving priority attention by regulators are the liberalization of VoIP and its interconnection to the PSTN, and the lifting of restrictions on spectrum to facilitate an expansion in the use of wireless broadband technologies (see also Purbo 2003).[11]

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 United States) may be dialed by users of the new technology. More often, however, questionable issues are also raised—mainly in the interest of incumbents—to justify regulation of VoIP 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 VoIP are minimal, and universal service funds are generally used in far less effective ways of achieving market penetration than competition between rivalrous networks, and it is not uncommon for universal service funds to be designed with considerable input from incumbents and to add barriers to entrants (Melody, Sutherland, and Tadayoni 2005).

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 available at very low cost to users, because the costs of setting up and operating 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, they are hardly justified in the context of rural communities in developing countries.

4. Donors and Governments committed to ICT development to reduce rural poverty, would do well to focus on
   1. the liberalization of VoIP and interconnection of VoIP to the PSTN, and
   2. the elimination of restrictions on the use of Wireless spectrum in the commonly license free bands that enable WiFi (2.4 Ghz and 5.8 Ghz) and WiMax (5.8 Ghz) networks;
   3. the increased availability of spectrum for licensed use by WiMax technologies in the 2.5-Ghz and 3.5-Ghz bands (WiMax Forum 2004; Reynolds 2006).

**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,

*tition 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, 4)*

*10. The literature on regulatory framework design is extensive (e.g., Eustache and Martimort 1999; Noll 1999; Srivastava 2000; Konvitz 2004).*

*11. "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).*

Vonage, and other companies with a commercial stake on the success of VoIP (Charny 2005). In the United States, ATT and MCI have been powerful supporters, among others (e.g., www.ipall.org), of the liberal treatment that the Federal Trade Commission 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.

5. Three kinds of interventions may contribute to such a buildup.
    1. Training in wireless networking, including administration and management of sustainable networks;
    2. Local wireless network projects that increase competition at the edge, filling a gap in rural broadband service;
    3. Local observatories of hot topics in telecommunications regulation, through which informed exchange, analysis, and debate about regulatory issues take place and, whenever appropriate, incumbents, politicians and regulators are called to task.[12]

## Concluding Remarks

Facilities based competition is the avowed objective of modern regulators, for example, in the United States, 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 composed of a large customer pool. In developing countries underserved areas are primarily composed of low-income rural communities dispersed over a wide geographic area. Competition is limited by the size of the commercially viable market.

Regulators are key determinants of investment risk. Although it is relatively easy to spell out conditions for good independent regulation, in practice obtaining independence has more to do with changing cultural mores and local tradition (i.e., factors that are difficult to change). And with little profits to be made from rural markets, there are few prospective market entrants willing to risk their capital to challenge the incumbent's economic and political dominance.

Wireless and VoIP are beginning to change the economic calculus of serving rural areas, but significant regulatory and governance obstacles remain. 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.

Government intervention and subsidies are required to stimulate demand and spur investment to serve rural communities. To the extent that these interventions are crafted to enable VoIP and wireless technologies to compete, these technologies will thrive. In the short term, the subsidies will have a high impact on rural communities. By increasing competitive pressure on incumbents, they will also have a significant long-term effect on the broadband development. ■

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*12. "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).*

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