Wireless Networks and Rural Development: Opportunities for Latin America

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Abstract

Recent developments in wireless local area network (WLAN) technologies are raising new hopes for sustainable Internet diffusion in the rural areas of the developing world. These technologies allow drastic reductions in network deployment costs, particularly for last-mile connectivity in low-density areas. More important, the technologies make possible an infrastructure development model based on community-shared resources, small-scale investments, and user experimentation. This paper argues that the new generation of WLAN technologies can significantly alleviate the constraints that limit Internet connectivity in Latin America to the wealthy, urbanized areas. Yet for this potential to be realized governments must rethink current assumptions about spectrum management and universal service policies.

Introduction

It is widely accepted that new information and communication technologies (ICTs) can be used to alleviate a wide range of obstacles for economic and social development in the developing world. This is particularly true of the Internet. As a global platform for accessing and sharing information, the Internet offers unique opportunities to overcome a variety of informational deficits that handicap people, businesses, and communities in poor nations (Castells 1999; Rodriguez and Wilson 2000). Studies have shown that increased productivity, better health, education, and government services result from widespread Internet adoption (Grace et al. 2001). However, many obstacles remain for widespread Internet adoption in the developing world, particularly outside the main urban centers (Norris 2000; Sarrocco 2002). A combination of poor telecommunications infrastructure, low population density, inadequate regulation, and high-cost technologies designed for urban markets makes Internet connectivity in many parts of the developing world a complex and costly proposition.

As a result, some researchers and donors have begun to question the cost-benefit rationale of extending Internet access to these high-cost, low-income areas. For example, Kenny (2002) argues that to address the informational needs of the rural poor, traditional technologies such as broadcast radio provide a more cost-effective alternative. Over the last decade, several demonstration projects have shown the benefits of Internet connectivity for a variety of rural development goals. However, long-term sustainability and wider-scale replication are rarely obtained (James 2003; Caspary and O'Connor 2003). The reasons are complex, but most researchers point to a combination of poor design and implementation that

does not properly account for local conditions, and the use of high-cost technologies developed for urban markets.

Recent developments in wireless local area network (WLAN) technologies are raising hopes for sustainable Internet diffusion in the rural areas of the developing world. These technologies allow drastic reductions in network deployment costs, particularly for last-mile connectivity in low-density areas. For example, remote rural villages can be serviced by asynchronous wireless systems that take advantage of available broadband connections in nearby communities, local data caching, and existing transportation infrastructure (e.g., roads) for long-distance traffic backhaul.[1] Such low-cost systems can be gradually scaled up or adjusted following revealed demand for ICT services, thus enhancing long-term sustainability.

What makes these technologies disruptive is not only the magnitude of reductions in deployment costs, but also that they make possible an infrastructure development model based on community-shared resources, small-scale investments in terminal equipment, and user experimentation (Best 2003; Bar and Galperin 2004). While we often think of Internet deployment as an undertaking for large commercial or government organizations, new WLAN technologies allow infrastructure to be built from the bottom up by a variety of local actors, from municipalities to user cooperatives. Because wireless technologies are not subject to the same economies of scale as traditional wireline technologies, sustainable deployment is possible at a much smaller scale, which allows local actors to regain an important role in the roll-out of infrastructure and ICT services. This enables networks to grow more closely tied to local contexts and community needs.

This paper argues that new WLAN technologies can significantly alleviate the constraints that limit Internet connectivity in Latin America to the wealthy, urbanized areas. However, for this potential to be realized, a number of regulatory obstacles need to be addressed. The first part of the paper provides an overview of the new breed of WLAN technologies that are fundamentally changing the

cost structure of Internet deployment—in particular the family of standards known as Wi-Fi. The second part discusses the implications of these changes for strategies to promote Internet diffusion in rural Latin America, and presents a brief discussion of a cooperative Wi-Fi project organized by farmers in rural Peru. The conclusion argues that more rigorous evaluations of demonstration projects are needed to assess the potential of WLAN technologies to bridge development gaps for the rural poor.

The Wireless Revolution: Development Implications

The deployment of telecommunications infrastructure has traditionally been associated with big investment programs undertaken by large entities such as telecommunications operators and government agencies. The reason is simple: only these entities were able to amass the sizable capital and attain the necessary economies of scale involved in laying down copper wires and providing expensive switching capacity to the network (Noll 2000). Over the past decades, however, technological progress in key areas of wireless communications and cost reductions in core equipment components have fundamentally changed the cost equation in favor of wireless solutions, particularly where no legacy wired networks existed. This has resulted in significant gains in basic telephony penetration among developing nations. Of the countries where penetration of mobile telephony first surpassed that of fixed lines, most were in Africa and Latin America (ITU 2003).

A similar process is now underway with respect to the delivery of Internet access services. Today, the level of Internet connectivity in the developing world is not only far below that of developed nations but also highly concentrated in wealthy urban areas (World Bank 2004). A number of studies have demonstrated that cost remains a major obstacle for broader Internet diffusion in these nations. In Latin America, for example, the cost of Internet use as a percentage of average monthly income is about 30 times higher than in the developed world.[2] The reality is that traditional Internet connectivity (i.e., resi-

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1. A good example is the system known as DakNet, which combines Wi-Fi with a mobile access point mounted on and powered by a public bus to provide e-mail and video message capabilities to rural villages in India (see Pentland et al. 2004).
2. Source: ITU (2004). This is calculated as the monthly price of 20 hours of use for residential customers.

dential dial-up or broadband) remains out of reach for all but a small urban minority. Aside from low per-capita income, there are several contributing factors. The preexisting telecommunications infrastructure is generally poor and unevenly distributed in favor of urban centers.[3] Leased-line costs and international connectivity, two key components of Internet access prices, are typically higher than in the developed world. In many cases, regulation discourages competition in the provision of backhaul services and last-mile connectivity (Wallsten 2003). Finally, in most rural areas low population density and high deployment costs discourage private investments, creating a negative feedback of limited capacity, high prices, and low service demand (Sarrocco 2002).

Recent (and future) developments in WLAN technologies are poised to impact the delivery of Internet services in the developing world comparable to that of cellular technology for basic telephony services. WLAN technology refers to a broad family of noncellular wireless communication solutions, which in practice include most of the technologies currently under the purview of the IEEE 802.xx standardization activities. While this encompasses a range of technologies with different attributes and at various stages of development, this paper focuses on the suite of IEEE 802.11 standards, also known as Wi-Fi. The reason is simple: this family of WLAN standards has gained broad acceptance and, as discussed in the next section, the level of penetration is such that Wi-Fi is fast reaching infrastructure scale.

The Unexpected Success of Wi-Fi

Like many technologies, Wi-Fi has evolved in a somewhat accidental way, taking an evolutionary path not envisioned by its creators and early backers. The technology was initially conceived as a wireless alternative for short-range connections between computers within homes and offices (i.e., a cordless Ethernet). However, it soon became clear that it could also be used to extend the reach of computer networks into public spaces. Moreover, both equipment vendors and wireless enthusiasts realized that, with the appropriate hardware and clever tinkering, point-to-point connections could be made over several kilometers. Wi-Fi has experienced extraordinary growth since 1997, when the IEEE finalized the original 802.11 specifications.[4] It is estimated that there are currently about 42 million Wi-Fi–enabled devices worldwide (Wi-Fi's Growing Pains 2004).

Among the many factors that explain the success of Wi-Fi, three are particularly noteworthy. (1) Wi-Fi can deliver high bandwidth without the wiring costs, which makes it an effective replacement for last-mile delivery, as well as for backhaul traffic where the installation and maintenance costs of wired infrastructure are prohibitive. (2) There is widespread industry support for the Wi-Fi standard, coordinated through the Wi-Fi Alliance, an industry organization including over 200 equipment makers worldwide.[5] As a result, equipment prices have dropped rapidly, and users can expect compatibility between Wi-Fi client devices and access points made by different vendors. (3) Key to the technology's success is the lack of regulatory overhead: Wi-Fi networks have blossomed on unlicensed bands, namely, thin slices of radio spectrum reserved for low-power applications in which radio devices can operate on a license-exempt basis (though, as we shall see later, this is not always the case). This has allowed for a wide variety of actors to build WLANs without the delays and expenses traditionally associated with obtaining a radio license from telecommunications authorities.

The major drawback of Wi-Fi is the short signal range. Even though point-to-point connections have been made over several kilometers, Wi-Fi networks typically extend for a few hundred meters at most. This makes the technology generally unsuitable for long-haul transmissions. Nonetheless, related technologies are emerging to address this problem, notably 802.16x (also known as WiMax). This new standard is expected to offer point-to-point connec-

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3. For example, according to the ITU (2004) the teledensity in the urban areas of Africa is about five times higher than in rural areas.
4. Today, Wi-Fi comes in three basic flavors: 802.11b, which operates in the 2.4 GHz frequency range and offers speeds up to 11 Mb/s; 802.11a, which operates in the 5 GHz frequency range and offers speeds up to 54 Mb/s; and the most recent 802.11g, which is backward-compatible with 802.11b but offers speeds up to 54 Mb/s. Work continues on variations that will improve the range, security, and functionality of Wi-Fi.
5. The Wi-Fi Alliance was formed in 1999 to certify interoperability of various WLAN products based on the IEEE 802.11 specifications. Since the beginning of its certification program in 2000, the group has certified over 1,000 products.

tivity at 70 Mb/s for up to 50 km, making it an ideal alternative for long-haul, high-capacity backbones in rural areas (ITU 2004). WiMax is also expected to include Quality of Service features that will facilitate the provision of VoIP services. Nonetheless, establishing baseline protocols for WiMax that would allow interoperability among equipment from multiple vendors has proved more complex than in the case of Wi-Fi. Interestingly, the unexpected success of Wi-Fi, coupled with the potential challenge that new WLAN technologies represent to the expensive 3G networks being deployed by mobile telephony operators, has significantly raised the stakes in the standardization process, bringing more players to the bargaining table and making agreements more difficult to reach.

Leapfrogging the Wired Internet

For developing nations, the combination of Wi-Fi with wireless backbone solutions, such as VSAT or the emerging WiMax standard, creates a significant opportunity to promote broadband connectivity in underserved areas at a fraction of the cost of alternative wired technologies, such as fiber and xDSL. A key factor is that WLAN technologies enable the delivery of broadband services even when the local telecom infrastructure is scarce and unreliable, which, as noted, is often the case outside urban centers. Network deployment costs are considerably lower since WLAN technologies involve minimal wiring expenses, which can comprise up to three quarters of the upfront costs of building traditional telecom networks (Caspary and O'Connor 2003). Instead of poles and wires, WLAN technologies take advantage of a natural resource typically underutilized in rural areas: the radio spectrum. Low-cost access systems based on Wi-Fi technology have already been deployed to service rural villages in Southeast Asia at a cost two orders of magnitude below that of comparable wired solutions (Best 2003; Pentland et al. 2004).

But the new generation of WLAN technologies brings more than cost reductions. It also challenges network deployment models linked to legacy wired technologies that tend to discourage investments outside wealthy urban centers. Laying telecom wires is not unlike paving roads. It requires large upfront investments; economies of scale are pervasive; and the architecture of the network must be carefully planned in advance because resources are not easily

redeployed. As a result, networks are typically built by large organizations in a top-down process that involves making many *ex ante* assumptions about how the services will be used, by whom, and at what price. However, these assumptions are easier to make in the case of well-understood, single-purpose networks (such as roads and sewage) than in the case of ICT networks, where applications and uses often result from the accumulated experience of users themselves (Bar and Riis 2000). And this is even more problematic in the rural areas of the developing world where demand for ICT services is complex to aggregate and difficult to predict (Torero 2000; Sarrocco 2002).

WLAN technologies create an alternative to the top-down network deployment model associated with traditional telecom infrastructure, an alternative better suited to the challenges of extending Internet connectivity to rural areas in the developing world. Because of the cost advantages associated with wireless, the use of unlicensed spectrum, and the lack of significant economies of scale in network deployment and management, infrastructure investments in Wi-Fi networks are within the reach of a variety of local actors—from private entrepreneurs to municipal governments to agricultural cooperatives—that better understand local conditions. A flexible infrastructure can therefore expand from the bottom up, without a preconceived plan, and better linked to the needs and attributes (geographical, demographic, economic) of local communities. Pilot initiatives with information kiosks in rural India have already demonstrated that a variety of ICT services can be provided by local entrepreneurs with minimal capital outlays (Best and Maclay 2002), while the wireless cooperative model pioneered in the United States is beginning to flourish in the developing world.

The new breed of WLAN technologies thus creates opportunities for developing nations to leapfrog the current generation of Internet access technologies, much like cellular telephony allowed leapfrogging the traditional public switched telephone networks (PSTNs). WLAN technologies combine cost advantages and flexibility with new deployment models in ways that significantly reduce capital expenditures, bypass regulatory bottlenecks, and minimize the coordination problems involved in deploying broadband in rural areas. This enables new policy strategies that address existing access

gaps in the developing world based on deployment of inexpensive WLANs by local entrepreneurs and community organizations for shared access in underserved rural areas. Yet, as discussed in the next section, a number of obstacles remain for such potential to be realized in Latin America and elsewhere.

Opportunities and Obstacles for WLAN Deployment in Latin America

Latin America is a continent of stark inequalities with respect to income and access to a variety of basic services. ICT services are no exception. While important gains have been made over the last decade with respect to basic telephony (as noted, largely because of the growth in mobile services) and Internet access, the region as a whole still lags significantly with respect to the developed world on the major ICT indicators (Hilbert and Katz 2003). Furthermore, evidence from within the continent reveals great disparities between urban and rural areas. Long-standing regional gaps in access to basic telecommunications have now been magnified in terms of access to new ICT services in most Latin American nations. Among the urban residents in Brazil, for example, 12.4% are regular Internet users, while only 1% of rural residents are online.[6] In Chile, 11.5% of urban households have Internet connections, while only 1.8% of rural households are connected.[7] In most rural areas of the continent there are few to no local ISPs, which translates into costly access due to long-distance charges for dial-up connectivity or lack of competition.

Addressing these gaps is critical for raising living standards in Latin America. While the region has undergone a rapid process of urbanization over the past decades, almost a quarter of Latin Americans still live in rural areas, and they are disproportionately poor.[8] Lifting rural residents out of poverty is a complex undertaking that involves a variety of development strategies, all of which presuppose better ICT access. First, several studies have demonstrated that ICTs improve productivity for the rural poor by reducing transactions costs and enhancing information flows in agricultural product and factor markets, including credit and information relevant to agricultural activities (Torero 2000; Eggleston et al. 2002). Second, the reality of rural communities in Latin America is that they increasingly depend on nonfarm activities, and attracting these activities requires reliable communication links to urban centers and a more educated workforce, both of which demand improved access to ICT services (de Janvry and Sadoulet 2000). Third, the administration and delivery of government services, and in particular, of social assistance programs for the rural poor can be improved dramatically through the use of ICTs (Heeks 2001). Finally, improved access brings about local empowerment, an important factor for the sustainability of rural development strategies.

WLAN technologies open new opportunities for addressing the lack of connectivity in rural Latin America, both in terms of reduced cost per connection and by allowing local organizations and entrepreneurs to become active participants in (rather than just recipients of) infrastructure development projects. A project in the Chancay-Huaral valley of Peru illustrates this potential.[9] The Chancay-Huaral valley is an agricultural region situated near the capital city of Lima. The majority of farmers in the region are small-property owners and the communications infrastructure available to them is scarce. This has two main implications. First, it puts farmers at a disadvantage due to deficient access to relevant market information. Second, it creates problems for the management of the waters of the river Huaral, a common resource used by the valley's farmers and managed by the board of users. The board is a cooperative arrangement of the 17 irrigation commissions spread throughout the valley, which are in turn composed of farmers themselves (about 6,000 in total). Faulty communication among

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these geographically dispersed entities often creates difficulties for efficient water management.

To address these problems, a Wi-Fi–based LAN was established linking 13 villages in the valley, most of them previously without telephone service. In each village, a small telecenter was equipped with 3–5 computers providing voice and data services between the villages as well as outside Internet connectivity through a shared 512 Kb/s line and a VSAT link. Ownership and maintenance of the network are in the hands of the board of users, which also manages an agricultural information system based on data collected by the irrigation commissions and specifically designed for the needs of farmers in the Chancay-Huaral valley. Training on the use of Internet tools and the agricultural information system is available in most locations. While most telecenters are housed by the local irrigation commission, some are located in educational institutions, making services available to teachers and students in the community. The total cost of the network equipment for the project was US$33,600, or about US$2,800 per village, with funding coming from external donors, the Peruvian telecommunications development fund (FITEL), and the board of users. The board expects to recover installation and maintenance costs by offering connectivity services to other community residents for a small fee.

The Chancay-Huaral project highlights the opportunities that exist for extending Internet connectivity into rural areas based on local resources and cooperative network management. The model offers a number of advantages. First, it allows the extension of services into areas where private returns are marginal or even negative. Cooperative self-provision enables the community to capture some of the positive externalities generated by network expansion (for example, more efficient management of shared water resources). Second, it allows the mobilization of nonmonetary resources that often prove critical for long-term sustainability, such as voluntary labor, rights of way, and the use of community facilities. Third, self-provision better addresses the actual information needs of the community, allowing users to be directly involved in the development of content and applications (in this case, farmers themselves collect some of the data aggregated in the agricultural information system, which also contains

information about educational and cultural activities in the communities). Fourth, local community involvement, long identified as a key factor in the sustainability of development projects, results naturally when community resources are at stake, as is the case in the Chancay-Huaral project. Finally, community ownership empowers local residents by building local entrepreneurial capacity and organizational skills.

On the other hand, the Chancay-Huaral project calls attention to the regulatory obstacles that exist in the region against expansion of network infrastructure based on wireless cooperative arrangements. The first problem encountered was that, under the existing rules, the board of users had to obtain a telecom operator license in order to terminate voice calls in the PSTN. This would trigger a number of obligations that the board would be unable to meet (including a contribution of 1% of operating revenues to the Peruvian telecommunications development fund!). As a result, the board has only been able to offer IP telephony within the network, although a number of alternative options are under evaluation, including renting lines from the incumbent operator (Telefónica de Perú) to allow the use of prepaid cards for call termination outside the Chancay-Huaral network.

The Availability of "Unlicensed" Bands
A second regulatory problem faced by the Chancay-Huaral project was the availability of the radio frequencies in the 2.4 GHz band for the operation of the Wi-Fi network. As noted, Wi-Fi networks have flourished worldwide on the basis of rules that provide for designated slices of the spectrum where anyone can build and operate a wireless network without the need to obtain a radio license. In the developing world, however, regulators have generally been slower to adapt legacy spectrum rules to enable WLAN deployment on a license-exempt basis. This is the case in Peru, where licensing rules for the 2.4 GHz band confine the operation of Wi-Fi devices to indoor spaces and impose power restrictions that severely limit the range of possible applications.[10] The board of users was therefore required to obtain a special permission from the telecommunications regulator (OSIPTEL) to build the Chancay-Huaral network.

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10. *These rules are codified in Article 25 of the* Reglamento General de la Ley de Telecomunicaciones.

Table 1. Licensing Rules for the Operation of Wi-Fi Networks in the 2.4 GHz Band

	Brazil	Chile	Mexico	Peru
Licensing basis	Secondary	Secondary	Secondary	Secondary
Power restrictions	400 mW in large cities	100 mW	650 mW	100 mW
Range restrictions	None	Indoor use only in certain regions	Outdoor use limited to 2,450–2,483.5 MHz	Indoor use only

Source: ANATEL (Brazil), SUBTEL (Chile), OSIPTEL (Peru), and SCT (Mexico).

In general terms, it is estimated that less than half of all developing nations have established rules for the operation of Wi-Fi radios over unlicensed bands (Leblois 2003).[11] While no comprehensive survey of the Latin American regulatory environment for unlicensed bands exists, the selected examples shown in Table 1 reveal that the Peruvian case is not unique. To begin with, licensing rules for the 2.4 GHz band in Latin America typically relegate Wi-Fi networks to secondary status, which means that devices must both accept interference from and avoid interference to primary-band licensees (these vary from country to country, ranging from fixed wireless data services to broadcasting news operations). In Chile, the regime for the operation of unlicensed WLANs is similar to that in Peru, characterized by strict power limitations and the prohibition to operate in outdoor spaces in certain regions (Regions VII, VIII, IX, and X) where primary band licensees are present (these regions represent 22% of the Chilean territory and 32% of the population) (SUBTEL 2004a, 2004b). In Brazil, the rules are more permissive, particularly outside urban centers of over 500,000 inhabitants (ANATEL 2004). Mexico lies somewhere in between, although outdoor operation is restricted to a small portion of the 2.4 GHz band (Secretaría de Comunications y Transporte 2001). Overall, much like in Africa, legacy spectrum rules discourage the deployment of Wi-Fi networks across the continent.

A related problem is the lack of harmonization in the rules for Wi-Fi network operation in the region. Differing rules discourage investments by regional players and prevent realizing economies of scale in equipment supply and services strategies. Licensing on a secondary basis similarly reduces investment incentives because no interference protection is granted from either peer low-power users, or more critically, higher-power primary licensees. The restrictions on outdoor utilization, coupled with power limitations, effectively reduce competition in the ISP market by discouraging entry from WISPs (wireless Internet service providers). This is significant because, contrary to the case of developed nations where the growth of Wi-Fi is driven by applications for mobile Internet access in restricted spaces (such as homes, offices and public hotspots), there is evidence that much of the Wi-Fi potential in developing nations lies in point-to-point connections that bypass backhaul services offered by the legacy carriers.[12] Overall, the effect of existing rules for "unlicensed" spectrum is to restrict market entry by entrepreneurs, local governments, and other nontraditional actors (such as the board of users), which reduces competition in Internet access services and in many cases perpetuates the neglect of rural, low-income communities not serviced by existing ISPs.

Conclusion

Extending Internet connectivity to rural areas in the developing world involves a delicate cost-benefit balance. While affordable access must be provided (and in some cases strongly subsidized), the social and economic returns must be high enough to enable long-term sustainability. The costs and deployment models associated with wired access technologies have often proved inadequate to strike this balance. Given the appropriate regulatory environment, WLAN technologies can significantly alleviate this problem. Cost advantages enable network

11. This is confirmed by a survey of African nations conducted by Neto (2004), which found that the majority of African nations (54% in the case of the 2.4 GHz band and 57% in the case of the 5 GHz band) still require a license from the telecommunications authority to operate WLAN devices in these bands.
12. See examples in Jaque (2003) and Neto (2004).

deployment in areas previously deemed unprofitable, and these technologies also allow local actors to gain an important role in the roll-out of infrastructure and services. This brings much-needed sustainability to ICT development initiatives, for such actors are typically best positioned to understand the characteristics of local demand for ICT services, as well as to leverage existing social networks and resources.

Much remains to be done before these opportunities are realized in Latin America and elsewhere. To begin with, more empirical studies are needed to formulate adequate development strategies based on wireless community networking. While the anecdotal evidence is encouraging, little is known about the cost effectiveness or long-term sustainability of a large-scale implementation. In this respect, demonstration projects that validate the benefits associated with cooperative Wi-Fi networks under a variety of local conditions are critical to educate policymakers. Ultimately, the goal should be to demonstrate that the new breed of WLAN technologies significantly broadens the range of policy alternatives for addressing existing connectivity gaps in underserved areas.[13]

From a regulatory perspective, there is much to be done to facilitate the deployment of WLANs in Latin America, whether by private entrepreneurs, public entities, or local organizations. As discussed, existing rules for unlicensed spectrum in most nations deter bottom-up experimentation with wireless community networking and restrict market entry by nontraditional actors. Another problem is the network development model associated with Universal Service funds. These funds were established in Latin America during the period of telecom liberalization in the 1990s for the extension of basic voice telephony services, but more recently have been expanded to include advanced ICT services such as broadband Internet.[14] In Chile, for example, the Telecommunications Development Fund was modified in 2001 to allow funding of a program that has to date financed almost 300 rural community telecenters through competitive tenders.[15] In Colombia, a similar program (called Compartel) has to date financed the installation of over 900 community telecenters across the country. In Ecuador, where it is estimated that 30,000 rural communities lack access to basic ICT services, resources are being allocated for the installation of community telecenters in 5,000 of them.

The increased use of Universal Service funds to finance telecenters in underserved rural areas is encouraging. However, these programs are generally linked to the traditional top-down development approach whereby public officials select the target locations and administer a competitive tender for the deployment of community access centers with clearly defined parameters in terms of which technology will be used, which services will be made available, how the telecenter will be operated, and so forth. The result is that, as the evidence from the aforementioned programs in Colombia and Chile reveals, most contracts are awarded to large operators or service aggregators, with little participation from local entrepreneurs and community organizations.[16]

The potential offered by new WLAN technologies calls for reconsidering the disbursement of Universal Service funds in favor of wireless community initiatives financed through microlending programs. Such a model, pioneered by the U.S. Rural Electrification Administration in the 1930s, has already proved successful elsewhere, most notably in the case of the Grameen Phone project (Prahalad and Hammond 2002). Though further research is needed, anecdotal evidence suggests that microlending programs can be an effective alternative for channeling public funds into ICT development projects. These programs could not only address connectivity gaps but also contribute to build local entrepreneurial capacity, a much-needed skill for the diversification of economic activities in rural Latin America. ■

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13. *A large-scale Wi-Fi demonstration project in the rural areas of Bolivia, Mexico, Paraguay, and Brazil is being evaluated by the author and others with funding from the Institute for Connectivity in the Americas.*
14. *Universal Service funds vary widely in the region in terms of definition, coverage, retail scheme, and funding mechanism. For a discussion see Estache et al. (2002).*
15. *See Wellenius (2001).*
16. *For example, in the case of Colombia's Compartel program, the contract for the development of community telecenters was split between Gilat (670 telecenters) and Telefónica (270 telecenters).*

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Abstract: Recent developments in wireless local area network (WLAN) technologies are raising new hopes for sustainable Internet diffusion in the rural areas of the developing world. These technologies allow drastic reductions in network deployment costs, particularly for last-mile connectivity in low-density areas. More important, the technologies make possible an infrastructure development model based on community-shared resources, small-scale investments, and user experimentation. This paper argues that the new generation of WLAN technologies can significantly alleviate the constraints that limit Internet connectivity in Latin America to the wealthy, urbanized areas. Rural economic development officers in Canada, for example, rank improvements in rural telecommunication infrastructure as more important than either improved health services or improved educational services, and cite poor telecommunication infrastructure as a primary factor in the out migration of professionals and the difficulty in attracting skilled professionals to relocate to rural areas (Ontario Federation of Agriculture, 1995). Attention should also be given to opportunities for Internet based copublishing efforts between information services in the North and stakeholders in the South. Latin america's economic and business overview. Latin America and the Caribbean (LAC)'s economies have lost growth momentum as countries grappled with deteriorating conditions. Economic growth has been weak over the last 5 years, while several countries have recently faced a complicated domestic environment â€" including political upheaval â€" and the external context has become less favourable, owing to the region's exposure to world commodity prices, global interest rate developments and global trade dynamics (IMF, 2020; OECD et al., forthcoming). The development of financial technologies (Fintech) brings new opportunities to increase financial inclusion (OECD et al., 2019). Wireless Networks and Rural Development: Opportunities for Latin America. Information Technologies and International Development, 2(3), 47-56. https://doi.org/10.1162/1544752054782420 Galperin, H., & Mariscal, J. (2007). Mobile Opportunities: Poverty and Mobile Telephony in Latin America and the Caribbean, DARSI (Dialogo Regional Sobre Sociedad de la Informacion). Galperin, H., Mariscal, J., Barrantes, R. (2014). Internet and poverty: Opening the black box.