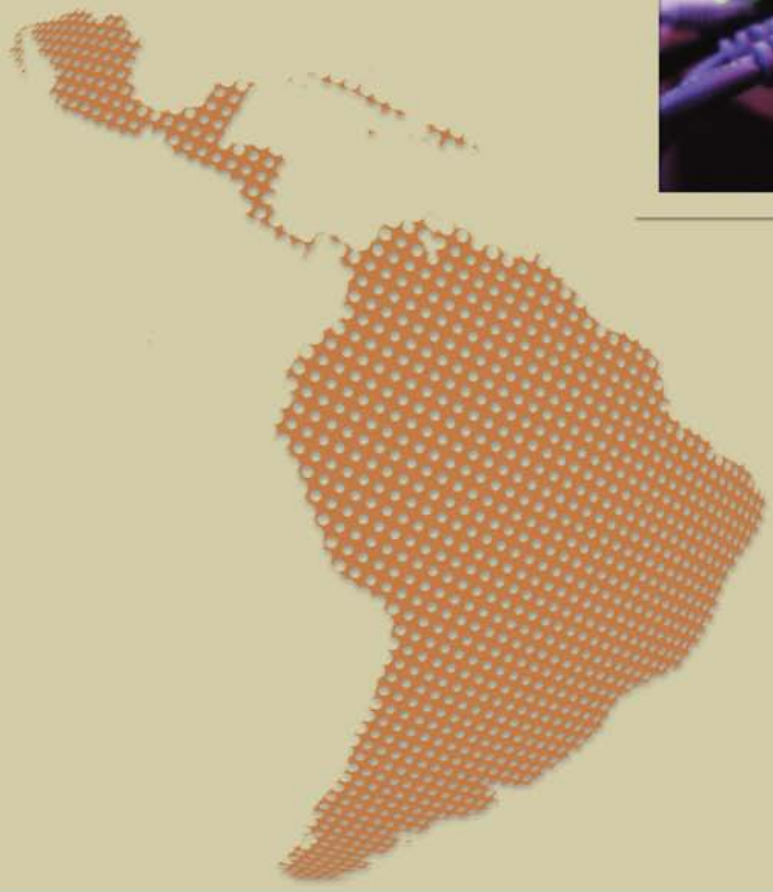
Economic Development and Inclusion through Local Broadband Access Networks



AUTHORS

Stefano Migliorisi (Tech4Dev)
Alessandra Balletti (Wi-ART)
Karl Edwards (Excelsio Communications)
Roberto Donà (NPV)
David Mendoza
Ugo Silva Dias
Miguel Collado di Franco
Luis Deza

EDITOR

Jaime García Alba (Multilateral Investment Fund)

Multilateral Investment Bank
Inter-American Development Bank
Washington, D.C.

MIF FOMIN

Multilateral Investment Fund

Economic Development and Inclusion through Local Broadband Access Networks

AUTHORS
Stefano Migliorisi (Tech4Dev)
Alessandra Balletti (Wi-ART)
Karl Edwards (Excelsio Communications)
Roberto Donà (NPV)
David Mendoza
Ugo Silva Dias
Miguel Collado di Franco
Luis Deza

EDITOR
Jaime Garcia Alba (Multilateral Investment Fund)

The Multilateral Investment Fund
Inter-American Development Bank
Washington DC

PROJECT TEAM
Stefano Migliorisi, Project Leader and Director of Tech4Dev; Alessandra Balletti, Peer and Desk Reviewer and Director of WiART; Karl Edwards, Technical Consultant and Chief Operating Officer of Excelsio Communications; Roberto Donà (NPV); Peer and Desk Reviewer and Director of the Double Degree in International Management at Bocconi University. The local consultants who participated in this project are: David Mendoza, Ugo Silva Dias, Miguel Collado di Franco and Luis Deza.

EDITOR
Jaime García Alba is an ICT Expert and Project Specialist of the Multilateral Investment Fund (MIF) of the Inter-American Development Bank (IDB).

The Series of MIF Monographs aims to stimulate discussion on issues related to the activity of MIF to improve practices that promote inclusive economic growth and poverty reduction through private sector development in Latin America and the Caribbean.

The MIF acknowledges the financial support received from the Italian trust Fund for Information and Communication technology for Development (IID) of the Inter-American Development Bank.

Publication of the Inter-American Development Bank, August 2009.

To request additional copies of this publication please contact:

Multilateral Investment Fund (MIF)
Inter-American Development Bank
1300 New York Avenue, N.W.
Washington, D.C. 20577

E-mail: mifcontact@iadb.org
Website: www.iadb.org/mif

Cataloging in Publication data provided by the
Inter American Development Bank
Felipe Herrera Library

Migliorisi, Stefano.

Economic development and inclusion through local broadband access networks / Stefano Migliorisi … [et al.] ; editor Jaime Garcia Alba.

p. cm. (Serie de Monografías FOMIN)
Includes bibliographical references.

1. Wireless LANs—Latin America—Case studies. 2. Wireless LANs—Caribbean Area—Case studies. 3. Broadband communication systems—Latin America—Case studies. 4. Broadband communication systems—Caribbean Area—Case studies. I. Garcia Alba, Jaime, ed. II. Inter-American Development Bank. Multilateral Investment Fund. III. Title. IV. Series.

HE7631 .M54 2009
621.382 M634----dc22

Cover Design: Joe García-IDB Design Unit BDA/GSV

MIF
FOMIN

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This study has been developed with the support of the Italian Trust Fund for Information and Communication Technology for Development. The theme of the study is the recent experience of community-based initiatives – driven by municipal governments, community organizations, local entrepreneurs associations, NGOs – that have deployed sustainable local broadband connectivity services. This report provides a detailed mapping of best practice for the implementation of sustainable local broadband access networks and an analysis of the situation in four countries in the Latin America and Caribbean region: Brazil, Dominican Republic, Guatemala and Peru. It is based on a desk review; phone interviews with stakeholders; mapping of existing best practices and country visits.

Elements of a Local Broadband Access Network

A local broadband access network is a network covering a limited area (e.g., a neighborhood, town, rural villages or province) and offering to the local population internet access and related services (e.g., phone calls, distance learning, telemedicine) at a speed higher than 256 kbps in one or both directions. Three general trends have made possible the mushrooming of local access networks worldwide: (i) progressive liberalization of telecommunications services over the last two decades; (ii) lower investment costs to set up a local broadband access network made possible by technological progress; and (iii) growing Internet penetration and emergence of broadband-enabled value added services.

Broadband penetration in Latin America and the Caribbean is very limited, extremely recent and concentrated in urban areas. It is therefore practically impossible to determine its economic impact and there is little quantifiable proof and no internationally comparable data of value. However, according to several studies on developed economies, there seems to be a clear link between broadband and GDP and employment growth through efficiency gains for businesses thanks to better connectivity

Broadband diffusion could be beneficial to developing countries for several reasons. First, the vast majority of people live outside urban centers and there is a need to minimize the migration from rural to urban areas. Spreading broadband to rural areas can increase efficiency and productivity and allow users to diversify their off-farm income and/or increase their farm income. Second, broadband can also help more people transitioning into the formal economy, thus enabling governments to raise more taxes and strengthen the basic infrastructure in rural areas. Third, ICT technology are generally more eco-friendly reducing the need for travel and CO2 emissions. Fourth, broadband allows access to better education, health and e-government services in a virtuous circle where improved know-how and health lead to further improvements in productivity and human capital.

The building blocks for productive broadband access are six:

1. **Skills.** The first step is the ability to fully use phones and computers. It is represented through a proxy (adult literacy rates) that reminds us that digital exclusion is often due to lack of education. In many marginalized areas, literacy rates are much worse than the national averages reaching peaks of 30-35% in some areas.

2. **Computers.** The second element is to own or have access to a personal computer. Only one family out five had a personal computer as of end 2007. Even though progress over the last five years has been impressive (with the share of households with computers almost doubling), few have access to a PC at home and will need to use it at work, school or at Internet centers.
3. **Internet Access.** Less than one household out of 10 has internet access at any speed in LAC, compared with three families out of four in developed economies. However, the percentage of Internet users is much higher (close to 22% on average) as many users do not access Internet from home.
4. **Broadband Access.** Only 3% of the LAC population has a broadband subscription. The number is not directly comparable with the number of households with Internet access because broadband subscribers include also companies and other entities. However, the share is extremely low compared to developed countries (19%) or the ideal target set by ITU (60%). There were nevertheless 23 million broadband connections in Latin America as of end June 2008. 65% of these connections had a speed higher than 512 kbps.
5. **Affordable Prices.** Broadband access is expensive in LAC, although still cheaper than in most developing countries. The cost of an annual broadband subscription is equal on average to 14% of per capita GNI, seven times higher than in developed economies.
6. **Acceptable performance.** Broadband to the home is useless if the overall Internet is congested due to low national or international bandwidth. The average international bandwidth per internet user in LAC was 8 kbps in 2007, up from 1 kbps in 2002. Such a bandwidth is however still too low when compared to the ideal target set by the ITU at 98 kbps.

A digital divide exists not only among but also within countries and may be due to any of the six factors reviewed above. Internet access is very limited in rural areas. Latin America and the Caribbean is the most urban region with only 21 percent of inhabitants residing in rural areas. According to the ITU, 96 percent of households have electricity including 87 percent of rural homes. Color TV reaches 75 percent of households overall and just under half of rural ones (46 percent). Fixed telephone is available in 36 percent of households but only 12 percent of rural homes. Mobile has a similar overall penetration in rural areas as fixed (33 percent) but many more rural households have mobile phones (21 percent on average). Home computer penetration is just 13 percent overall and only 3 percent in rural households while Internet penetration is 7 percent overall and only 1 percent in rural homes.

Enabling Environment

The cost, availability and performance of broadband access are affected first and foremost by the overall business environment. An enabling environment for local broadband access networks is the combination of regulatory frameworks and physical infrastructure that enables the establishment, diffusion and sustainability of such networks. Particularly in developing nations, regulations need to encourage rather than restrict competition, even by small players, while investment is necessary to support the intermediate infrastructure that in turn enables successful diffusion of broadband networks.

Power outages are still a major problem for several countries in the Latin America and Caribbean region, particularly in Central America and the Caribbean. Lagging areas in the region are often densely populated and the only option for many has been migration. Better **transport and communication infrastructure** can be an alternative to migration allowing improved access to wealthier markets. The Rural Access Index (RAI) – maintained by the World Bank – is a simple indicator that measures the proportion of the rural population that

has adequate access to the transport system. All four countries included in our case studies have a very low RAI between 40% and 60%.

The **overall business environment** is not conducive in several countries in the region. The ease of doing business is very limited in several countries in the region, while only Chile, Colombia, Mexico and a few Caribbean countries have an easy business environment, according to the World Bank's Doing Business database. While a difficult business environment should not stop investments in broadband access networks, it certainly limits a country's ability to reap the full benefits it could derive from them.

ICT Regulations. Most countries in the region have witnessed a significant level of private investment in infrastructure, indicating a wide liberalization of access to the related sectors. ICT policies impact the following areas: spectrum use policies, licensing, Voice over Internet protocol, interconnection tariffs, quality of service requirements, infrastructure and facilities sharing.

Spectrum use policies. New wireless technologies and infrastructure which can be deployed for very little cost compared to traditional wired alternatives have dramatically increased the demand for spectrum. Spectrum is the physical medium through which all wireless technologies transmit and receive information. Radio is the term used for the portion of the electromagnetic spectrum in which waves can be generated by applying alternating current to an antenna. Radio spectrum is the essential resource underpinning wireless communications.

Being spectrum a scarce resource, regulators have to cope with the need to define new efficient policies for frequency bands management if they want to promote access for remote areas and underserved areas. The most immediate policies are based on increasing the amount of unlicensed spectrum. In many Latin American ones, there are restrictions on the use of the 2.4 GHz and 5 GHz bands used in Wi-Fi/WIMAX networks. In recent years, countries in the LAC region have been reforming spectrum administration, allowing for an increased unlicensed use by low-power devices (such as Wi-Fi) in these bands.

Licensing Regime. Use of the electromagnetic spectrum in most bands is tightly controlled by licensing legislation. Burdensome licensing requirements and high licensing fees undermine the opportunity of a financial return that will ensure sustainability. Geographical extension requirements for service provision and lengthy administrative procedures represent barriers to investments, particularly for small operators and those intending to invest in rural areas where margins are smaller. In addition, some regulation policies require separate licenses for different kinds of services.

Voice over Internet protocol (VoIP). VoIP is a set of facilities used to manage the delivery of voice information over the Internet and has become increasingly popular, particularly for long distance and international calls where prices on the PSTN are high. A significant, although decreasing, number of countries have banned or restricted the use of VoIP mainly because it deprives incumbent operators of revenues that could otherwise support the expansion of universal access. In some cases, for example, burdensome taxation is levied on VoIP calls. According to our interviewees, less than half of Latin American countries (38%) have authorized the use of IP networks to provide telephony services. In most cases, VoIP is neither completely legal nor illegal. Lack of legal protection has discouraged further investment.

Interconnection. Interconnection refers to the linkage used to join two or more communications units, such as systems, networks, links, nodes, equipment, circuits, and devices. The most critical issues when dealing with interconnection are:

- the **tariff**, which in case of rural operators may undermine a local broadband network's sustainability
- the **risk of delaying tactics** from the dominant operators.

Quality of Service. Regulations concerning quality of service may not recognize that it could not always be possible to guarantee the same quality of service in rural as in urban areas. In rural and remote areas technicians might not be as promptly available to repair faulty equipment as in urban areas. Furthermore, where VoIP services are provided in rural areas over wireless and satellite technologies, quality or service may be even more difficult to maintain given possible interruptions in terms of power supply and connectivity. In this context, strict quality of service requirements may be an impediment to investment in rural networks.

Infrastructure and facilities sharing. Local operators need to be protected from anti-competitive strategies by the incumbents in control of access to higher-level facilities. Typical reasons why small and medium size localities, in addition to rural areas, are underserved in terms of broadband services are either because there is a single operator with nearby fiber that sells capacity to local ISPs at high prices or because local telecom/cable operators lack incentives or resources to upgrade networks.

Strategic Choices in Establishing a Local Broadband Access Network

There are four strategic choices that need to be made when setting up a local broadband access network:

1. **Technology.** Each network need to connect homes and business among themselves and to the Internet. To do so there is a need to consider different technological options, wired and wireless. The final choice is influenced by the geography of the location, the type of services to be offered to the local population and the distance from the backbone.
2. **Funding.** Once the network is designed, its deployment must be funded. Often public funding and donor initiatives have proven essential for bringing connectivity to rural areas, while, on the other hand, they have undermined the for-profit approach which is essential for long term sustainability.
3. **Value added services.** Availability of broadband is only an enabling factor. The use and ultimately the success of a local broadband access network are based on offering services that are tailored to the needs and means of the local population.
4. **Business Model.** Public-private partnerships and the involvement of local stakeholders are two crucial aspects of any successful local broadband access network.

Technology. There are three different segments in a local broadband access network:

- **Backbone** (connectivity to the Internet)
- **Backhaul** (connectivity between points of presence/access points and the backbone)
- **Last Mile** (connectivity between points of presence/access points and customers - residential or business)

Each segment can use wired or wireless technologies. Access to the Internet backbone for example could be through fiber optic cables, DSL, satellite, Wi-Fi Mesh or WiMax. The last mile could be through fiber to the

home, DSL or Wi-Fi, just to name a few. The choice for each segment can be different and adapted to specific local conditions; possible combinations are many.

Three factors affect the technology adopted for network architecture. Local geography is among the key elements to analyze when designing a local broadband access network. In some cases local geography may pose heavy constraints on network feasibility. Where, as in the case of Peru, wide mountainous areas are present, additional equipment for the backhaul network or satellite link is needed. The distance from the backbone is another key factor: wired options can be too expensive and wireless may be the only way to go. Finally, the type of services required matters.

Funding. Public funding and donor initiatives have often proven essential for bringing connectivity to rural areas, but they also run the risk of undermining the for-profit approach which is essential for long term sustainability. Central and local authorities could help local access networks first and foremost by using them, thus guaranteeing a constant stream of revenue, acting as the main customer ("anchor tenant") of the network. A government's own activities as a user of telecommunications can therefore lead to direct financing of major components of new networks and services, which can help expand the market and reduce risk. In thin markets, business revenues, including the highly important public institutions such as municipality, schools, libraries, police, etc., can serve as the anchor tenant from which to enter consumer and small business markets. It is unlikely that revenues from household subscribers alone can drive development of broadband in such thin markets.

Universal Access Funds or Universal Service Funds (USF/UAF) have been present in many countries for decades, but unfortunately many of these have not been as effective in narrowing the urban-rural digital divide as desired. By far the most progress in this arena has been achieved where countries enable the private telecom sector to make investments, specifically in the mobile market. However, there is still the need for a public policy that establishes and manages well-constructed universal service funds.

In addition to public funding, local broadband access networks can be funded through:

- **Public-private partnerships**
- **Voluntary networs,** where groups of people within a community work together towards providing high-speed Internet access
- **Carrier Expansion,** where mobile operators expand service to rural and underserved communities;
- **Micro-credit for microtelcos,** where emerging small or very small local operators can be funded through traditional micro credit.

Services. Local Broadband Access Networks can serve different communities with different services:

- **Urban underserved areas.** Typically small and medium size towns, in addition to rural areas, are underserved in terms of broadband services, either because there is a single operator with nearby fiber that sells capacity to local ISPs (which results in high retail access prices) or because local telecom/cable operators lack incentives or resources to upgrade networks. Low income population has no access to broadband services.
- **Non remote rural communities** for which the type of network depends on the size of the community, the geographic extension and the distance from existing network facilities.

- **Remote rural communities** which can be reached through a combination of broadband wireless access technologies and satellite link.

The ultimate value of a network for served communities is not represented by the technology in itself, but by the value added services that it delivers. These services have to meet local demand and willingness to pay. Whether or not people choose to make use of services depends on:

- **Affordability** - i.e., the extent to which the price of broadband internet services represents an efficient use of the economic income
- **Ease of use** - in terms of information and communication capabilities and education required to access the service and benefit from its use
- **User value** - i.e., the extent to which broadband internet service improves the user's quality of life

A winning approach needs to include network stakeholders when defining the portfolio of services. Successful initiatives are therefore based on service offerings which, especially in the case of remote and underserved areas, have to be tailored to the economy of the communities they serve and to low-to-moderate income consumers.

Choice of Business Model

There are four business models used in Latin America and the Caribbean for local broadband access networks:

- the **public network model**, where all investments and operating costs are borne by local authorities (e.g., municipality, district, province, region, state) with or without private sponsors. Access can be either (a) limited to public institutions (including hospitals, libraries and schools) where citizens can use broadband services for e-government or any broadband service, depending on the network's policy; or (b) offered anywhere to anyone for free (e.g., Muniwireless);
- the **telecenter model**, a location within a community that contains a number of computers that are connected to the Internet. Telecenters have been the first broadband providers to emerge for several reasons. First, getting broadband access to one location (the Telecenter) has been possible in several areas of the developing world for a relatively long time. Second, many Internet users cannot afford computers but can pay reasonable Telecenter fees. Their success, however, especially when sponsored by donors, has been fairly limited.
- Local broadband access networks are often built and operated by **micro-telcos**, small-scale telecom operators that combine local entrepreneurship, innovative business models, and low-cost technologies to offer an array of ICT services in areas of little interest to traditional operators Microtelcos typically have between 200 and thousands subscribers in communities with more than 10,000 inhabitants.
- Smaller communities – with less than 10,000 inhabitants and a potential subscriber pool between 50 and 200 users – are served by **nano-telcos**. The main difference is technological. While micro-telcos can often afford WiMAX, nano-telcos use point-to-multipoint Wi-Fi or Wi-Fi-mesh.

Successful business models have several core features: a strong private-public sector partnership, local stakeholder involvement, ICT and management capabilities in the local community, and a set of realistic objectives and strategies with a coherent business plan.

The study also analyzes the development of local broadband access networks in Brazil, Dominican Republic, Guatemala and Peru. The most favorable combination is present in Brazil and the least favorable in Guatemala. The Dominican Republic and Peru are in between these two extremes. About 60 local broadband access networks were identified during the country visits.

The study ends with a series of recommendations on how to improve access to broadband in rural areas.

1. INTRODUCTION

This report is aimed at identifying general patterns from the recent experience of locally operated access networks in rural and underserved urban areas. These bottom-up initiatives, leveraging on and combining new wireless local networking (WLAN) technologies – such as VSAT, Wi-Fi and the emerging WiMAX – and innovative business models, have proven successful in providing broadband connectivity and ICT services in areas of little or no interest to traditional operators. The report attempts to fill the existing gap of knowledge on the details of the technological, organizational, governance and financial aspects of these initiatives, and has explored the opportunities for implementation of these models in four countries of the Region (i.e., Brazil, Dominican Republic, Guatemala and Peru).

The methodology followed in preparing the study is described in **Annex 4**.

2. WHAT IS A LOCAL BROADBAND ACCESS NETWORK?

A local broadband access network is a network covering a limited area (e.g., a neighborhood, town, rural villages or province) and offering to the local population internet access and related services (e.g., phone calls, distance learning, telemedicine) at a speed higher than 256 kbps in one or both directions. These five elements are briefly described below.

- **Network.** A network is a series of points or nodes interconnected by communication paths. Networks can be characterized in terms of spatial distance as local area networks (LANs), metropolitan area networks (MANs), and wide area networks (WANs). The networks we analyzed in this study are MAN or WAN that can carry both voice and data, are public and have always -on connections using any technology. We do not cover private or dial-up networks.

- **Limited area.** A local broadband access network covers a local community ranging from a town or a province or a region. It could also cover under-served urban sub-areas (for example, a slum).

- **Local population.** These networks need to provide open access for the entire local community: public and private, business and residential. Access could of course be either free or for a fee.

- **Internet access and related services**. The main purpose of these networks is to provide access to the Internet but this may not be the main service offered though. Using voice-over-IP, the provider may offer voice services (local and/or regional and/or national and/or international phone calls), telemedicine (i.e., access to a skilled physician through videoconferencing and remote control of medical equipment), e-learning (the ability, for example, of a student from the Amazon to get a university degree using a computer and webcam without having to migrate to an urban area) or e-government services (e.g., access to municipal authorities for certificates and permits).

- **High speed**. The speed of a connection (also called its "bandwidth") is the amount of data that can fit through it per second. It is expressed in thousands (kbps) or millions (Mbps) of bits per second. The definition of "broadband" or "high speed connection" varies from country to country and different international organizations use different minimum speeds for broadband: 128 kbps (Partnership on Measuring ICT for Development), 256 Kbps (OECD) or 256 kbps in one or both directions (ITU). In this study we use the ITU definition of broadband: any always-on connection to the Internet at a speed of 256 kbps or higher in one or both directions.

3. ECONOMIC DEVELOPMENT, DIGITAL INCLUSION AND LOCAL BROADBAND ACCESS NETWORKS

While quantifiable data on the impact of broadband Internet are still very limited, it is nevertheless clear that broadband development does have significant macro-economic impact. Broadband roll-out has a more powerful impact than basic telephony. It not only allows people to communicate but also to do business more efficiently, get access to better education and health services and benefit from better government services.

As shown in the following pages, broadband penetration in Latin America and the Caribbean is very limited, extremely recent and concentrated in urban areas. It is therefore practically impossible to determine its economic impact and there is little quantifiable proof and no internationally comparable data of value. However, according to several studies on developed economies, there seems to be a clear link between broadband and GDP and employment growth through efficiency gains for businesses thanks to better connectivity. An econometric research carried out by the MIT[1] on US data found that "between 1998 and 2002, communities in which mass-market broadband was available by December 1999 experienced more rapid growth in employment, the number of businesses overall, and businesses in IT-intensive sectors, relative to comparable communities without broadband at that time. " Of course, to have an impact broadband had to be used, not just available and attention should always be given to demand-side policies. Broadband added about 1-1.4% to the employment growth rate and 0.5% to 1.2% to the growth of business establishments during the period 1998-2002. Another study of the USA estimated that "for every percentage point increase in broadband penetration in a particular area, employment would increase 0.2 to 0.3 percentage points per year.[2]"

Broadband diffusion could even be more beneficial to developing countries for several reasons. First, the vast majority of people live outside urban centers and there is a need to minimize the migration from rural to urban areas. Spreading broadband to rural areas can increase efficiency and productivity as in the case of the USA presented above, and allow users to diversify their off-farm income and/or increase their farm income. Second, broadband can also help more people transitioning into the formal economy, thus enabling governments to raise more taxes and strengthen the basic infrastructure in rural areas. Third, ICT technology are generally more eco-friendly reducing the need for travel and CO2 emissions. Fourth, broadband allows access to better education, health and e-government services in a virtuous circle where improved know-how and health lead to further improvements in productivity and human capital.

The economic impact of broadband is highly dependent on the overall environment that needs to be enabling, as discussed in the next section. Reliable energy is essential as computers and networks cannot run without it. E-commerce cannot prosper without an efficient logistic system that allows agricultural produce to move fast. Broadband expansion alone cannot do miracles.

---

[1] Sharon E. Gillett et al., *Measuring Broadband's Economic Impact*, prepared for the U.S. Department of Commerce, February 2006, p. 3.

[2] Robert Crandall, William Lehr and Robert Litan, "The Effects of Broadband Deployment on Output and Employment," June 2007.

Figure 2 on the next page compares Latin America and the Caribbean and developed economies using ITU data. Details on each country are included in **Annex 1**. The building blocks for productive broadband access are six:

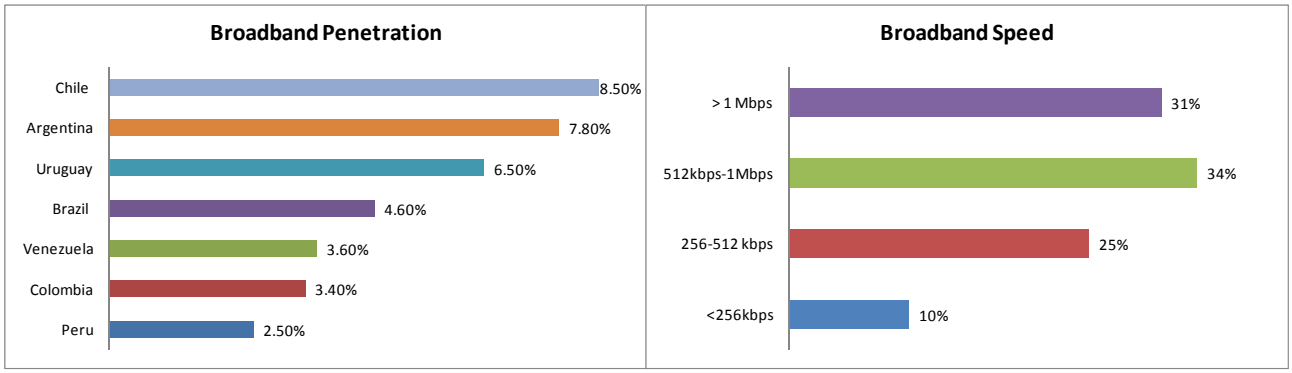
1. **Skills**. The first step is the ability to fully use phones and computers. It is represented through a proxy (adult literacy rates) that reminds us that digital exclusion is often due to lack of education. In many marginalized areas, literacy rates are much worse than the national averages reaching peaks of 30-35% in some areas. A few projects in Brazil for example have focused on how to adapt Internet tools to the needs of illiterate citizens, while phone services can be used even with very basic literacy. On average, a vast majority of the population in LAC should be able to use a computer.

2. **Computers**. The second element is to own or have access to a personal computer. Only one family out five had a personal computer as of end 2007. Even though progress over the last five years has been impressive (with the share of households with computers almost doubling), few have access to a PC at home and will need to use it at work, school or at Internet centers.

3. **Internet Access**. Less than one household out of 10 has internet access at any speed in LAC, compared with three families out of four in developed economies. However, the percentage of Internet users is much higher (close to 22% on average) as many users do not access Internet from home.

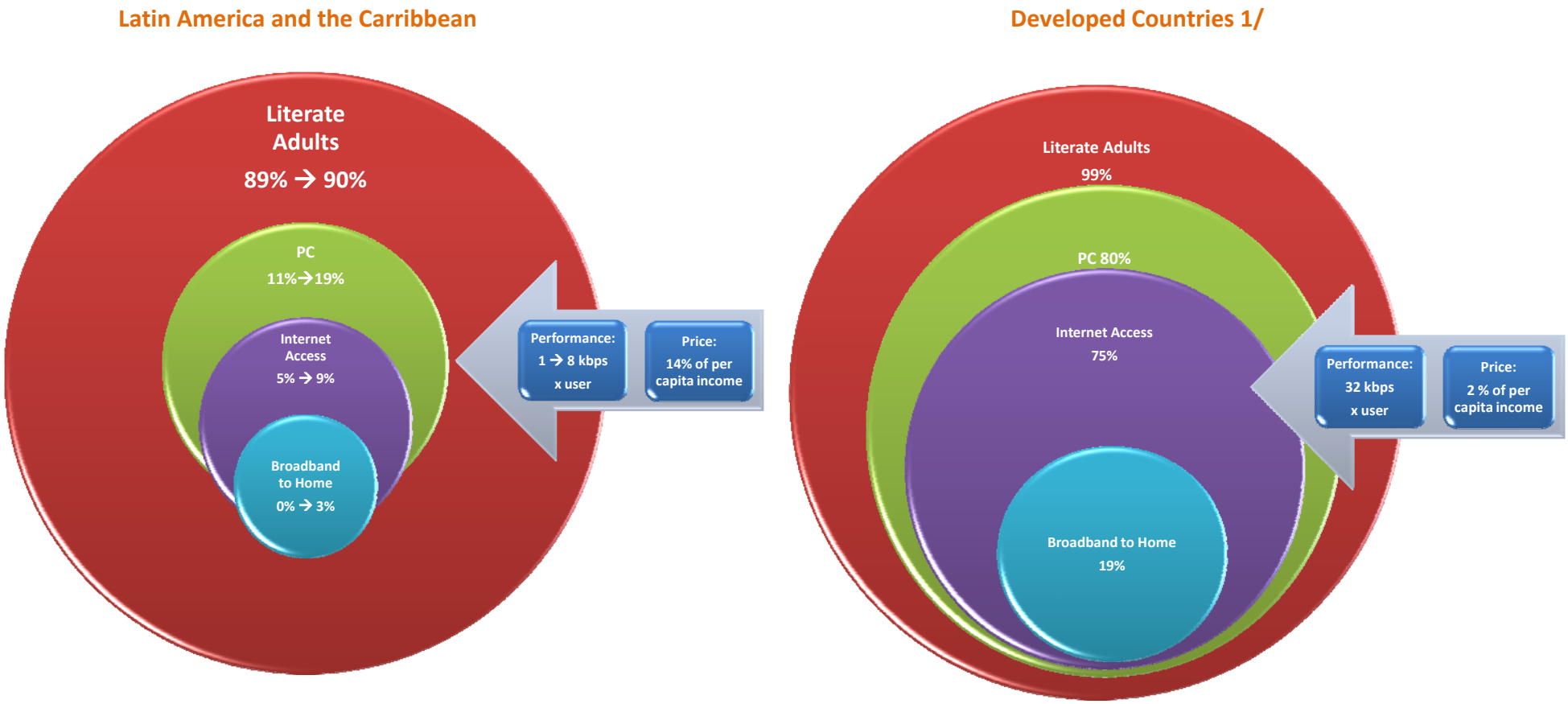
4. **Broadband Access**. Only 3% of the LAC population has a broadband subscription. The number is not directly comparable with the number of households with Internet access because broadband subscribers include also companies and other entities. However, the share is extremely low compared to developed countries (19%) or the ideal target set by ITU (60%). According to an IDC study sponsored by Cisco[3], there were nevertheless 23 million broadband connections in Latin America as of end June 2008. 65% of these connections had a speed higher than 512 kbps, as shown in **Figure 1**.

Figure 1 - Broadband Penetration and Speed in Latin America as of June 2008



[3] IDC, Cisco Broadband Barometer, 2008.

Figure 2 – Comparison of Broadband Diffusion between Latin America and Developed Countries



1/ Using the United Nations classification of developed/developing countries. See http://unstats.un.org/unsd/methods/m49/m49regin.htm

Source: ITU (2009). Data for LAC refer to the countries included in **Annex 1**. The first figure at the left of the arrow refers to 2002, the one to the right to 2007. Data on developed economies refer only to 2007.Performance refers to the international bandwidth per Internet user.

5. **Affordable Prices.** Broadband access is expensive in LAC, although still cheaper than in most developing countries. The cost of an annual broadband subscription is equal on average to 14% of per capita GNI, seven times higher than in developed economies.

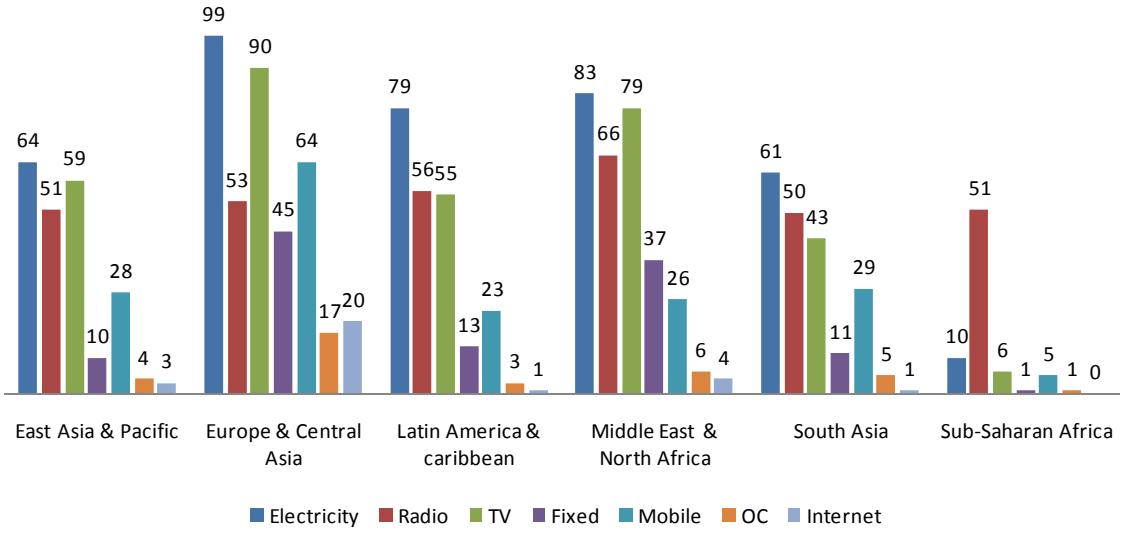
6. **Acceptable performance.** Broadband to the home is useless if the overall Internet is congested due to low national or international bandwidth. The average international bandwidth per internet user in LAC was 8 kbps in 2007, up from 1 kbps in 2002. Such a bandwidth is however still too low when compared to the ideal target set by the ITU at 98 kbps.

The cost, availability and performance of broadband access are affected first and foremost by the overall business environment as discussed in the net section. Wherever the environment is enabling, the impact of different models to deliver broadband access to local communities is certainly greater.

A digital divide exists not only among but also within countries. OECD[4] defines "digital divide" as the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities. Digital inclusion is understood here as any activity aimed at bridging the digital divide.

Figure 3 shows how limited Internet access is in rural areas. Latin America and the Caribbean is the most urban region with only 21 percent of inhabitants residing in rural areas. 96 percent of households have electricity including 87 percent of rural homes. Color TV reaches 75 percent of households overall and just under half of rural ones (46 percent). Fixed telephone is available in 36 percent of households but only 12 percent of rural

Figure 3 - Percentage of Rural Households with ICT access by Type and Region, latest available data



[4] OECD (2001). Understanding the Digital Divide. Paris.

homes. Mobile has a similar overall penetration in rural areas as fixed (33 percent) but many more rural households have mobile phones (21 percent on average) including over half of rural homes in Paraguay. Home computer penetration is just 13 percent overall and only 3 percent in rural households while Internet penetration is 7 percent overall and only 1 percent in rural homes (source: ITU).

Digital exclusion may be due to any of the six factors reviewed above. Segments of the population may be excluded, for example, because (a) they do not know how to use a computer (e.g., they may be illiterate or simply have never used a computer before); (b) they do not own a computer because they do not need it, cannot afford it or do not have electricity at home; (c) they have no narrowband and/or broadband Internet access because no provider is reaching the area where they leave; (d) the quality of the broadband they receive is not sufficient for the applications they most need (e.g., telemedicine, e-learning); and/or (e) they cannot afford to pay broadband subscription fees.

Any policy to broaden access to broadband by all segments of the population needs to understand the cause of digital inclusion. Too many policies focus only on availability of broadband access without understanding that availability alone will not guarantee use. An interesting example from Brazil is presented in **Box 1** below.

Box 1 - Local Broadband Networks to Achieve Digital Inclusion: an Example from Brazil

Pilot projects in Brazil have gone beyond the network itself and focused also on services for the digitally excluded (from illiterate people to deaf and visually impaired citizens). CPQD, a state owned research center in Campinas, has developed kiosks conceived for illiterate citizens and, given that only 20% of Brazilians have PCs (although the trend is on the rise) but over 90% own TVs, has developed a digital TV with locally manufactured set tops working on TV frequencies and easily programmable at municipal level. Illiterate citizens can for example use menus made of multimedia icons. To schedule a visit with their doctors, they can click on his/her picture and hear the options read to them aloud through the computer.

4. WHY ARE THEY SPREADING SO FAST?

Three general trends have made possible the mushrooming of local access networks worldwide:

1. Progressive Liberalization of Telecommunications services over the last two decades
2. Lower Investment Costs to set up a local broadband access network made possible by technological innovations
3. Growing Internet Penetration and emergence of broadband-enabled value added services

Progressive liberalization of telecommunication services worldwide. Starting in the late 1990s, many developing countries attempted to create more transparent and stable legal and regulatory frameworks, with national regulatory authorities and opening certain market segments, such as mobile voice, to competition. Their main objectives were to attract investment and to move closer to universal access to basic telecommunication services. As noted by ITU, "drastic changes in the sector have since flowed from technological innovation, convergence of services, and growing competition. These changes may now require a further regulatory shift to open more market segments to competition and update licensing and spectrum management practices in order to foster growth in broadband networks and converged services. A rise in competition and new service providers will also require an enhanced focus on dispute resolution."

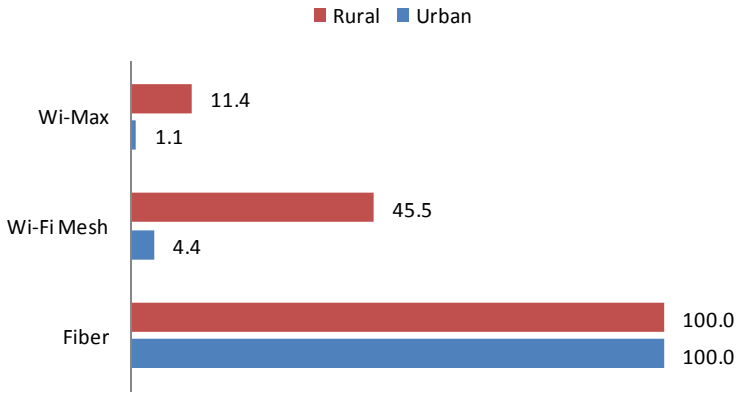
As of October 2008, 152 countries had created a national regulatory authority for their ICT and telecommunication sectors. By mid-2008, 125 ITU member countries had a privately-owned, or partially privatized, national fixed-line incumbent. **Table 1** below shows the situation in a sample of Latin American and Caribbean countries with a clear predominance of fully-private operators.

Table 1 - Main fixed line operators in Latin America and the Caribbean by type

Country	*Main fixed line operator*
Argentina	Fully private
Bolivia	Fully private
Brazil	Fully private
Chile	Fully private
Colombia	State owned (50)/Partially Private (50)
Costa Rica	State owned
Dominican Republic	Fully private
Ecuador	State Owned (50)/Fully Private (50)
Guatemala	Fully private
Jamaica	Fully private
Mexico	Fully private
Panama	Partially Private
Paraguay	State owned
Peru	Fully private
Trinidad & Tobago	Partially Private
Uruguay	State owned
Venezuela	Mostly Fully private

Lower Investment Costs to set up a local broadband access network. The cost of setting up a metropolitan or a wide area network has dropped dramatically over the last decade. "Wireless local loops are about one third the cost of copper or fiber land-lines, while packet-based broadband computer networks cost one ninth of land-line service. Ease of set-up, use, and maintenance are affordable for both users and providers."[5] Our estimates, summarized in **Figure 4** (see **Annex 4** for a description of the methodology followed in preparing these estimates), show that the savings through wireless technologies can be substantial. Customer premise equipment as well as access points are reasonably priced, while wireless technologies allow reaching customers without digging and laying cables. Wired services like DSL which uses existing telephone copper wires is also a cheaper option for the last mile, even though its potential is lower in many developing countries due to the limited fixed line penetration in many areas, the low quality of wires and the distance between multiplexers which makes it practically unfeasible in rural areas.

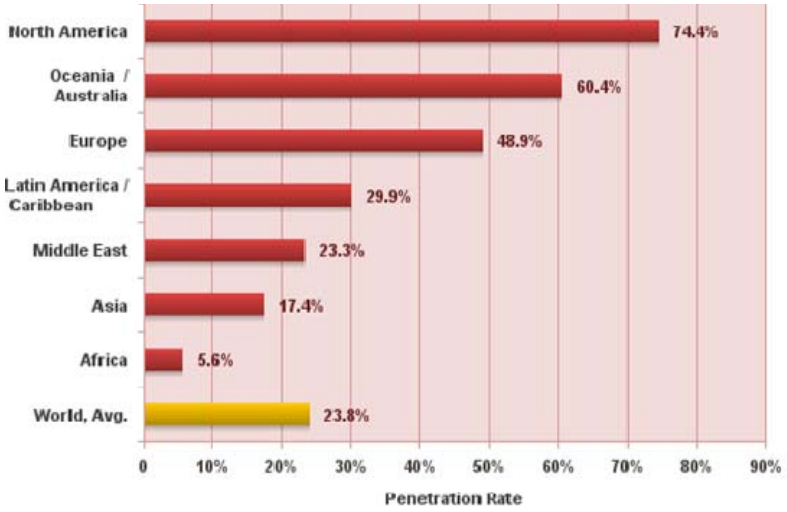
Figure 4 - Cost of network per square mile by Type of Technology (Fiber=100)



Growing Internet Penetration and emergence of broadband-enabled value added services. As shown in **Figure 5** below, the degree of internet penetration is very high in developed countries and is catching up rapidly in Latin America and the Caribbean where it is now close to 30% of the population. Most of Internet based services (e.g., e-learning, telemedicine, e-commerce, voice over IP) require broadband connections, to the point that narrowband Internet access is almost equivalent to no access at all. As a consequence, wherever possible, Internet access is broadband. In Chile, for example, almost 90% of Internet access is through broadband. The percentage is lower in other countries in the region.

[5] Wireless Internet Institute, *The Wireless Internet Opportunity for Developing Countries*, p. xiv.

Figure 5 – World Internet Penetration Rates by Geographic Region



Source: Internet World Stats - www.internetworldststs.com/stats.htm
Penetration Rates are based on a world population of 6,710,029,070 and 1,596,270,108 estimated Internet users for March, 2009.

5. AN ENABLING ENVIRONMENT FOR LOCAL BROADBAND ACCESS NETWORKS

An enabling environment for local broadband access networks is the combination of regulatory frameworks and physical infrastructure that enables the establishment, diffusion and sustainability of such networks. As noted recently in The Economist, "broadband networks are not helpful without a reliable power supply and the widespread availability of personal computers[6]." Particularly in developing nations, regulations need to encourage rather than restrict competition, even by small players, while investment is necessary to support the intermediate infrastructure that in turn enables successful diffusion of broadband networks. The World Bank in fact found that in industrialized countries, if a technology reaches 5% of the market, it is highly likely to reach 50% of the market. However, in emerging markets, only six of 67 technologies that reached 5% of the market went on to capture 50% due to lack of the necessary intermediate infrastructure[7].

Physical Infrastructure

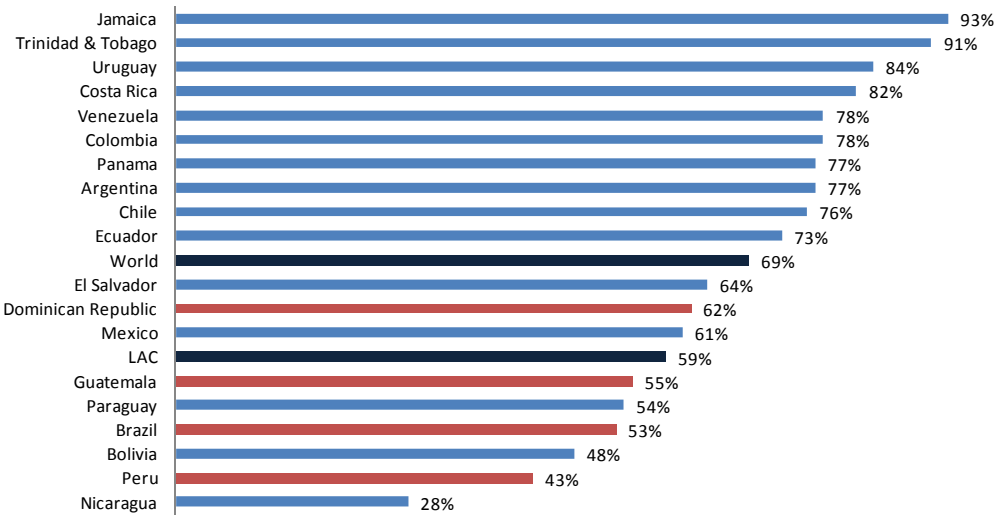
Power outages are still a major problem for several countries in the Latin America and Caribbean region, particularly in Central America and the Caribbean. Lagging areas in the region are often densely populated and the only option for many has been migration (as in the case of Brazil's North East: twenty percent of poor men born there now live in its prosperous Southeast searching not only for better wages but also for better public services). Better transport and communication infrastructure can be an alternative to migration allowing improved access to Southeast markets. Lower communication costs have allowed the growth of international production networks. Broadband allows to control production processes over long distances by computer-aided control systems and online communication. However, research shows that within countries, improving transport infrastructure may lead to more concentration of economic activity, not less.

With few exceptions, the quality of the existing telecom infrastructure is also an issue. For example, lack of backbone infrastructure linking local access networks to the Internet is a real bottleneck to the expansion of commercially-viable broadband networks into rural areas and into the interior of many countries. This is especially true for those programs aiming to provide bandwidth-intensive applications and integrated voice-data IP services.

The Rural Access Index (RAI) – maintained by the World Bank – is a simple indicator that measures the proportion of the rural population that has adequate access to the transport system. All four countries included in our case studies – as shown in **Figure 6** - have a very low RAI between 40% and 60%.

[6] "The Limits of Leapfrogging," The Economist, February 7, 2008.
[7] World Bank, Cross-Country Historical Adoption of Technology (CHAT) database. Cited in Intel (2009), *The Economic Impact of Broadband in Developing Nations*.

Figure 6 - Rural Access Index (RAI) in Latin America and the Caribbean



Source: World Bank

Overall business environment

The overall business environment is not conducive in several countries in the region. the ease of doing business is very limited in several countries in the region, while only Chile, Colombia, Mexico and a few Caribbean countries have an easy business environment, according to the World Bank's Doing Business database. While a difficult business environment should not stop investments in broadband access networks, it certainly limits a country's ability to reap the full benefits it could derive from them.

ICT Regulations

Most countries in the region have witnessed a significant level of private investment in infrastructure, indicating a wide liberalization of access to the related sectors. ICT policies impact the following areas: spectrum use policies, licensing, Voice over Internet protocol, interconnection tariffs, quality of service requirements, infrastructure and facilities sharing.

Spectrum use policies. New wireless technologies have dramatically increased the demand for spectrum. Being spectrum a scarce resource, regulators have to cope with the need to define new efficient policies for frequency bands management if they want to promote access for remote areas and underserved areas. The most immediate policies are based on increasing the amount of unlicensed spectrum (see **Box 2**).

Dedicated unlicensed spectrum currently exists and has been allocated by the World Radio Conference (WRC) in the 2.4 and 5.0 GHz band. Wi-Fi technology can be used to provide Internet access in the 2.4 GHz and 5 GHZ bands. Spectrum authorities in North America and Europe have designated these bands as unlicensed spectrum that can be used by anyone for the provision of Wi-Fi services. The availability of this spectrum has been one of the main reasons for the widespread deployment of local access networks based on Wi-Fi and WiMAX technologies in these areas.

Box 2 - Licensing Regime and Local Broadband Networks – an Example from Brazil

An interesting example about the influence of the licensing regime on investment decisions is provided by Ruralfone Inc., a Company founded in 2002 with the aim of providing the most affordable basic phone service with an exclusive focus on small to medium sized villages and cities in developing areas. Local is Ruralfone's Brazilian subsidiary. Brazil was selected as a basis for Ruralfone operations essentially for two main reasons:

- Ease of getting a license - At the level of independent companies or organizations, there is no regulation limiting the way in which internal telecommunications are structured, managed, and priced and the business model that can operate within the existing legal framework. Ruralfone applied for a national license but the service can be operated on a regional base (regional licenses are available; and
- possibility to use mobile frequencies for fixed applications.

In recent years, countries in the LAC region have been reforming spectrum administration, allowing for an increased unlicensed use by low-power devices (such as Wi-Fi) in these bands.

Factors which may still limit the use of unlicensed frequency bands are:

- **Power, geographic and other location limits**. In many countries power restrictions significantly limit outdoors deployment opportunities and thus the appeal of the technology for new service providers**.** Such restrictions have been removed in Peru where transmitting power for Wi-Fi is limited to 1Watt in urban areas, while it can be higher in rural areas.
- **Potential spectrum congestion and interference** affecting the quality of transmissions, and ultimately, the quality of the service delivered to the final user, especially if due to licensing rules which do not protect Wi-Fi bands from interference by a range of sources, from wireless data services to broadcasting news operations.

Burdensome licensing requirements like high licensing fees undermine the opportunity of a financial return that will ensure sustainability.

Also geographical extension requirements for service provision, lengthy administrative procedures represent barriers to investments, particularly for small operators and those intending to invest in rural areas where margins are smaller. In addition, some regulation policies require separate licenses for different kind of services. WiMAX frequencies are often subject to lengthy administrative procedures for obtaining a license. In addition, the geographic extension of the license together with coverage obligations may prevent the entry of local operators.

Voice over Internet protocol (VoIP). VoIP is a set of facilities used to manage the delivery of voice information over the Internet and has become increasingly popular, particularly for long distance and international calls where prices on the PSTN are high. A significant, although decreasing, number of countries have banned or restricted the use of VoIP mainly because it deprives incumbent operators of revenues that could otherwise

support the expansion of universal access. In some cases, for example, burdensome taxation is levied on VoIP calls. According to our interviewees, less than half of Latin American countries (38%) have authorized the use of IP networks to provide telephony services. In most cases, VoIP is neither completely legal nor illegal. This has not prevented many local entrepreneurs from offering VoIP services. In most countries in the region, telecenter operators offer long-distance calls over broadband connections at a fraction of the cost of incumbent carriers. Analysts[8] estimate that Latin America accounts for 35% of global VoIP traffic (compared to 9% of PSTN). Yet, lack of legal protection has discouraged further investment.

Lifting restrictions on the provision and use of VoIP, particularly for rural operations, would support the deployment of local broadband networks and service take up among communities which often lack basic telephony services. In the Dominican Republic, VoIP is provided by local operators (among which Bec-Tel through its WiMAX network). In the recent past the incumbents opposed VoIP initiatives, but Indotel ruled in favor of this technology.

Interconnection. Interconnection refers to the linkage used to join two or more communications units, such as systems, networks, links, nodes, equipment, circuits, and devices. The most critical issues when dealing with interconnection are:

- the **tariff**, which in case of rural operators may undermine a local broadband network's sustainability
- the **risk of delaying tactics** from the dominant operators.

In the Dominican Republic, Guatemala and Peru, for example, interconnection is left to the market to resolve, making interconnecting difficult if not impossible for new entrants. The regulator has limited scope of action and although it can intervene through moral suasion, it is not equipped to force an agreement. The end result is that calls cannot sometimes be terminated between local carriers.

Asymmetric charges for the interconnection of rural networks to existing backbone networks may significantly contribute to the economic sustainability of local broadband access networks. The Peruvian regulator OSIPTEL has studied more favorable regulatory and other conditions for rural operators. These include: a differentiated licensing regime for rural areas, with little or no spectrum license and usage fees in rural areas to encourage investment, reduced coverage obligations for rural operators and asymmetric interconnection and tariff arrangements between the rural operators and others.

Quality of Service. Regulations concerning quality of service may not recognize that it could not always be possible to guarantee the same quality of service in rural as in urban areas. In rural and remote areas technicians might not be as promptly available to repair faulty equipment as in urban areas. Furthermore, where VoIP services are provided in rural areas over wireless and satellite technologies, quality or service may be even more difficult to maintain given possible interruptions in terms of power supply and connectivity. In this context, strict quality of service requirements may be an impediment to investment in rural networks. Operators may be daunted by high quality of service requirements or they may have to spend considerably more in order to meet quality of service requirements. Such requirements discourage seeking price/quality

[8] Telegeography.

combinations better suited for specific local areas, and reduce opportunities for bypassing essential facilities controlled by incumbents.

Infrastructure and facilities sharing. Local operators need to be protected from anti-competitive strategies by the incumbents in control of access to higher-level facilities. This general case is particularly relevant for small operators, who cannot bargain effectively with incumbents and typically lack the resources or expertise to wage lengthy regulatory or judicial battles. In addition, sharing of facilities such as towers and other resources offers opportunity for reducing costs. Typical reasons why small and medium size localities, in addition to rural areas, are underserved in terms of broadband services, are either because there is a single operator with nearby fiber that sells capacity to local ISPs at high prices or because local telecom/cable operators lack incentives or resources to upgrade networks.

Tariffs. Rigid regulations on tariffs and engineering standards discourage price/quality differentiation and affect the service economic sustainability. The operator/ISP should be allowed to freely establish prices and offer access to the Internet under the most suitable tariff plan. Telecommunications service costs are most often a function of the telecommunication regulatory regime and past license awards that have had the effect of limiting competition. Internet costs are due to lack of adequate infrastructure – fiber optic or wireless backbone networks – which allows owners of existing backbones to charge high prices. The result is effectively a very limited access to service and a barrier to network sustainability.

Partnership Arrangements. A suitable legal structure has to be flexible enough to support different partnership structures and business models, in particular public-private partnerships. Municipal governments are an important actor in the provision of ICT services and much of the value may come from institutional services and access to facilities made available by local institutions. In Latin America, there have been several decentralization programs aimed at increasing local government autonomy, creating an enabling institutional setting for the delivery of public services at municipal level. Possible roles recognized by legislation for Municipalities are:

- Authorities **aggregate demand**, require e-government applications support in network/service planning and provide training to potential users.
- Municipalities enter into public-private partnerships with private operators to **co-finance the network**.
- Local authorities engaged in the **building and operation of a non-competitive network segment** (e.g., a fiber backbone) on a wholesale basis.

Import duties on foreign equipment that cannot be obtained domestically can drive up costs dramatically, especially for smaller operators and act as inhibitors to the deployment of local broadband networks.

If the environment is enabling, there are four strategic choices to make

If the environment is enabling, there are four key strategic choices that need to be made when setting up a local broadband access network:

- **Technology (Section 6).** Each network need to connect homes and business among themselves and to the Internet. To do so there is a need to consider different technological options, wired and wireless.

As we will see, the final choice is influenced by the geography of the location, the type of services to be offered to the local population and the distance from the backbone.

- **Funding (Section 7).** Once the network is designed, its deployment must be funded. Often public funding and donor initiatives have proven essential for bringing connectivity to rural areas, while, on the other hand, they have undermined the for-profit approach which is essential for long term sustainability.
- **Value added services (Section 8).** Availability of broadband is only an enabling factor. The use and ultimately the success of a local broadband access network are based on offering services that are tailored to the needs and means of the local population.
- **Business Model (Section 9).** Public-private partnerships and the involvement of local stakeholders are two crucial aspects of any successful local broadband access network.

These choices are inter-related. For example, the type of services offered influence the technology. The start-up cost depends on the technological choice and the preferred business model. The strategy formulation process is therefore not a linear progression from one choice to the next but requires several iterations.

6. TECHNOLOGY

Technological progress over the last decade has been one of the major factors behind the growth of local access networks worldwide. The evolution of technology has followed the familiar pattern of personal computers. Networks used to be like mainframe computers: very expensive, difficult to maintain and operate, and affordable only for the largest corporations. Wireless technologies, like personal computers, have caused a systemic change, making small, low cost networks feasible. In this chapter, written as much as possible in non technical language, we review the technological options available for today's micro-telecom operators and explain how they can be combined to match widely different local conditions in rural and marginalized areas of Latin America. All these technological combinations have one common thread: affordability.

There are three different segments in a local broadband access network:

- **Backbone** (connectivity to the Internet)
- **Backhaul** (connectivity between points of presence/access points and the backbone)
- **Last Mile** (connectivity between points of presence/access points and customers - residential or business)

Each segment can use wired or wireless technologies. **Table 2** below summarizes the wired and wireless technological options that could be used for each segment. Access to the Internet backbone for example could be through fiber optic cables, DSL, satellite, Wi-Mesh or Wi-Max. The last mile could be through fiber to the home, DSL or Wi-Fi, just to name a few. The choice for each segment can be different and adapted to specific local conditions; possible combinations are many.

Table 2 - Wireline and Wireless Technologies for access and backhaul networks

Type	*Name*	*Technology*	*Used in*	
			Access	Transport
Wireline	Cooper Local Loop	Digital subscriber line (DSL)	X	
		Integrated Services Digital Network (ISDN)	X	
	Coaxial Cable Systems	DOCSIS	X	X
	Fiber optic cable systems	Dedicated Line, Hybrid Fiber Cable	X	X
	Power Transmission Line	Power Line Communications (PLC)	X	
Wireless	Radio in the loop	GSM,GPRS,EDGE, UMTS, HSPA, LTE	X	
		Wi-Fi, WiMAX	X	X
	Geostationary and low earth orbit satellites	Satellite, VSAT	X	X

There are several factors affecting the technology adopted for network architecture. Local geography is among the key elements to analyze when designing a local broadband access network. In some cases local geography may pose heavy constraints on network feasibility. Where, as in the case of Peru, wide mountainous areas are present, additional equipment for the backhaul network or satellite link is needed. The distance from the backbone is another key factor: wired options can be too expensive and wireless may be the only way to go. Finally, the type of services required matters. In Brazil, for example, Local Telecom provides phone services to several cities using a local GSM network. Phone calls are offered at a fixed monthly cost but are limited to local calls. In such an environment, there is no need to interconnect with the national network and distance from the backbone becomes irrelevant.

The various technological options are briefly reviewed below.

Wireline Technologies

Fiber can support speeds in the Tbps range. Compared to coaxial technologies, fiber has superior quality because it has no crosstalk, no electromagnetic or radio interference, no degradation of capacity due to distance, and is less expensive to maintain. It is widely used in the deployment of broadband networks, especially for the backbone connectivity. Cost of deployment is the main drawback.

DSL. Cost of DSL connections is minimal in an urban environment as it exploits the existing copper wires, while it is unfeasible in rural areas because of the degradation of signal over distance in DSL connections (if the distance from the closest multiplexer is greater than 18,000 feet, DSL does not work).

Wireless Technologies

GSM-GPRS/EDGE. Global System for Mobile (GSM) services are the de facto global standard for mobile telephony. The General Packet Radio Service (GPRS) and its evolutions (EGPRS, EGPRS2) is the associated data

capability built on top of GSM networks. While theoretically capable of handling 120 Kbits/second for GPRS, 600/1200 Kbits/second for EGPRS/EGPRS2, the rate is actually closer to 60 Kbit/s for GPRS and 300kbps for EGPRS which is only marginally acceptable. The cost of a greenfield installation can be relatively high, but expansion of existing second and possibly third generation systems can be cost-effective, because the major component of capital cost is in the installation of new base stations. The network, consisting of the local access, transport, and network management components, would also have to be expanded. However, the cost of adding new subscribers and capacity is usually marginal, as these functions are shared by all users.

Broadband wireless access (BWA) systems. Wi-Fi (IEEE 802.11 Standard), originally established for indoor use (i.e. a cordless Ethernet) and capable of 11 Mbits/second, has gone external and can now reach speeds of 54 Mbits/s. Each hotspot can provide coverage within a radius of a few hundred meters of a Wi-Fi base station. For small communities, a single array of Wi-Fi directional antennas can provide coverage within a diameter of 4-5 km. Used in a point-to-point mode Wi-Fi can also serve as a backhaul transmission link with line-of- sight ranges that can easily reach up to 20 km. The covered area depends on antenna gain and the transmission power applied to the radio, which can be higher in rural areas than in urban areas for the 2.4 MHz unlicensed band.

Wi-Fi Mesh architecture relies on the deployment of multiple Wireless Access Points, each with multiple radios. Wi-Fi Mesh technology can be adopted to build a network in and around towns/villages by covering an area of hundreds of km, using some Wi-Fi nodes with mesh capacity. Wi-Fi mesh nodes can be set on top of silos, water towers, or poles. The system supports data and VoIP. Another advantage is robustness: when each end-user is connected to several others, multiple data routes may be available, thus bypassing failed nodes. This architecture is gaining popularity in creating large metropolitan "clouds" as well as a strategy to cover large rural areas.

Mesh networking protocols are well suited to the following business cases (see **Box 3**):

- local networks where backhaul links are scarce and expensive as is the case in many rural areas,
- where spectrum is congested (e.g., urban slums), since each network node needs only transmit as far as the next node.

Box 3 - Reasons for Wi-Fi success

Among the many factors that explain the success of Wi-Fi:

- Wi-Fi can deliver high bandwidth without 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.
- Widespread industry support for the Wi-Fi standard, coordinated through the Wi-Fi Alliance, an industry organization including over 200 equipment makers worldwide. 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
- 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 discussed later in this report - this is not always the case). Such exemption has often allowed a wide variety of actors to build WLANs without the delays and expenses traditionally associated with obtaining a radio license from telecommunications authorities.

Both Wi-Fi and Wi-Fi Mesh antennas can also be solar powered. With VoIP, Wi-Fi and Wi-Fi Mesh networks are capable of providing both voice and data. Phone instruments for GSM and CDMA are increasingly becoming available with Wi-Fi built into the handset. A growing number of end-user instruments (VoWi-Fi phones, Pads, PCs.) are being offered with built-in Wi-Fi.

Worldwide Interoperability for Microwave Access (WiMAX)[9] is built off of the 802.16 and ETSI HIPERMAN standards. The 802.16 standard offers fixed and mobile access. Being standard-based brings to WiMAX following advantages:

- Cost effective and high-quality solution,
- Flexible in using certified, compatible and interoperable equipments from different vendors

Compared to wired broadband technologies, WiMAX has the following advantages[10]:

- Cheaper implementation costs,
- Lower monthly ongoing maintenance costs,
- Quicker and easier setup/deployment/reconfiguration/disassembly
- More scalability and flexibility for future network expanding

While WiMAX vendors often claim to be able to cover distances up to 50 km, a more realistic expectation is 5-8 km and depends on the propagation environment. The 802.16 standard offers fixed, line of sight (LOS) links up to 75Mbps in licensed frequencies, though much lower rates are likely to be realized in most situations. WiMAX can support also full mobility solutions based on the 802.16e standard. Compared to Wi-Fi, WiMAX has a higher entry cost due to license fees and infrastructure investments. Although the costs of the Customer Premise Equipment (CPE) and lack of end-user terminals may at present result in a major factor limiting deployments, there is a rapid adoption of WiMAX across a growing number of countries.

Depending on the frequency band of transmission, on the propagation conditions (Line of Sight, Non Line of Sight), and on the propagation environment, the WiMAX customer premises equipment (CPE) can be an indoor or outdoor one. In the case of indoor CPE, the subscriber installs the CPE by simply plugging it into a power source and then connects to it a terminal which can be a residential VoIP telephone, a computer or a public payphone. **Table 3** below presents a comparison between Wi-Fi and WiMAX.

[9] Nair, G.; Chou, G.; Madejski, T. ; Perycz, K. ; Putzolu, D. and Sydir, J. - *IEEE802.16 medium access control and service provisioning*, Intel Technology Journal,Vol. 8, No. 3, 2004.

[10] Matiæ, D. - *Introduction to OFDM, II Edition, OFDM as a Possible Modulation Technique for Multimedia Applications in the Range of mm Waves,* http://www.ubicom.tudelft.nl/MMC/Docs/introOFDM.pdf, 1998.

Table 3 - Wi-Fi versus WiMAX

Wi-Fi	*WiMAX*
Wi-Fi is a wireless local area-networking (WLAN) standard developed by the IEEE 802.11 working group.	WiMAX is an 802.16 standard-based technology
It is used for close-range indoor applications and for Internet accessing of a group of computers/device in a small environment (hot spot). External modification to the standards through hardware and software allows Wi-Fi products to become a metro-access deployment option. Each standard 802.11type (a,b,g) uses a different frequency and radio modulation technology.	WiMAX can be used for a last-mile wireless broadband to implement Wireless Metropolitan Area Network (WMAN)
In Wi-Fi networks, as the number of users increases, the efficiency of the network decreases; while in 802.11 g standard, a single user can access 30 Mbps bandwidth, but as the number of users increases, the per user throughput decreases. Also the range of the Wi-Fi system is not very large. Wi-Fi works in unlicensed spectrum using the 2.4 and 5GHz bands. Wi-Fi is a cheap and easy way of providing local connectivity at high speed	WiMAX uses licensed spectrum and has strong authentication mechanisms built in. It has considerably greater range than Wi-Fi. WiMAX base station can beam high speed Internet connections to homes and businesses in a radius of up to 50km (31 miles). These base stations can cover an entire metropolitan area, transforming that area into a WMAN and allowing true wireless mobility within it, as opposed to hot spot hopping by Wi-Fi. WiMAX standard has the spectrum range from 2 to 11 GHz. This technology supports 70 Mbit/s of shared data rate. with enough bandwidth to simultaneously support more than 60 businesses with T1-type connectivity and well over a thousand homes at 1 Mbit/s DSL level connectivity.

Table 4 contains WiMAX applications for local broadband networks in the urban, remote rural and non remote rural scenarios and a comparison of Wi-Fi and WiMAX technologies.

Table 4 - WiMAX applications

Type	*Pro versus wired solution*	*Usage scenarios*
WMANs, wireless broadband access to metropolitan areas	Save deployment cost due to copper wires. With wired MAN, the QoS/Throughput may also be limited by the distance and the quality of wiring (DSL line quality depends from the length of the cable between the DSL multiplexer and the user)	Urban underserved areas
Rural Area BroadBand Services	The quality of broadband services depends on both the access network and the interconnection between the local access points and the backbone network. The cost of the backhaul increases with distance**.** In rural area the cost will be unaffordable to many of the users for wired solution. WiMAX is the best choice owing to its low cost and ease of deployment but with similar performance as DSL. Besides WiMAX network is highly scalable because the cost of adding a new cell is substantially lower than that in a wired network.	Remote rural communities (also with Satellite backhaul), Non remote rural which are further from existing backbone networks connecting to the Internet.
Last Mile High Speed Access to Buildings	WiMAX can be used instead of wired lines. Compared to wired alternatives, WiMAX can provide broadband services in a more flexible way (NLOS transmission), at a lower cost but with comparable speed. PMP connections are typically used to link a central location to a group of other locations in this case	Provide high speed link for particular buildings (e.g. School, Hospital)
Wireless Backhaul	WiMAX can be used as a high-capacity with lower cost than landline backhaul (T1/E1 lines).	Backhauling for cellular system and Wi-Fi hot spots. WiMAX can combine multiple Wi-Fi hot spots together into a cluster and fill the gap between their coverage areas.

A WiMAX deployment can also serve in combination with Wi-Fi and Wi-Fi Mesh as the longer-distance distribution method with a Wi-Fi solution used for establishing multiple local hotspots or clouds. The backhaul capacity required depends on the number of customers, the traffic type (continuous such as in business uses or intermittent such as in residential uses). For a village with 50 customers, a 128 Kbps link may be enough; however, for more intense use a 2 Mbps (E1) or faster link may be needed[11].

CDMA 2000. Code Division Multiple Access (CDMA) is a family of third-generation CDMA cellular communications standards that supports voice and data. It has a reasonable presence in the Asian market with scattered, though growing, number of implementations in other countries, including in Latin America and Caribbean. Evolution Data Optimized (EV-DO) is the CDMA-based data service and is capable of handling up to 3.1 Mbits/s. In addition to greater data capacity, the EV-DO technology covers greater distances than GSM. It represents a viable option for rural areas (see **Box 4**). CDMA450 combines an established, competitive cellular standard (CDMA2000) with an unconventional yet promising frequency spectrum (450MHz), previously allocated to cellular carriers using analog standards and now left unused as these technologies became obsolete.

[11] Ahson, Syed and Ilyas, Mohammad - *WiMAX Applications* , CRC Press - September 2007

Box 4 - Wireless is more than just Wi-Fi vs. WiMAX. The Case of CDMA450 in Mexico.

Telmex deployed a CDMA450 network provided by US mobile technology firm QUALCOMM. The network will be used to deliver services to 7,225 rural communities. Apart from voice, the network allows SMS, fax, email and broadband internet access over the 450Mhz spectrum band. Telmex has been planning to use WiMAX throughout Latin America to deploy wireless last mile solutions. In fact, the company currently holds a license in Mexico in the 3.5Mhz band that could be used for a WiMAX deployment. The company chose to deploy CDMA450 rather than WiMAX in this case because the CDMA450 network is able to achieve widespread national coverage with a smaller infrastructure investment and lower costs. A WiMAX network would have needed 20 times the amount of base stations.

The network is already available commercially and will focus first on voice and data. The CDMA450 allows for an eventual EVDO upgrade for faster data as well, which will depend on how its commercial deployment evolves.

Satellites have been in place for decades, providing global coverage. The more recent developments have been the IP-based satellite services such as those provided by i-Direct, IPSTAR, and Inmarsat (RBGAN & BGAN). Depending on the specific location of deployment, there are a range of satellite options. IPSTAR is a satellite delivering pure IP bandwidth to the Asia-Pacific region by using the latest modulation and beam-forming technologies. The broadband satellite's overall bandwidth capacity is 45 Gbps and it can provide a bandwidth of up to 4 Mbps down and 2 Mbps up to an individual end user location. By combining a satellite backhaul with broadband wireless technology, connectivity can be distributed to many users rather than a single user as is done in traditional deployments. This increases the economic viability of such a deployment in rural areas. BGAN is conceived for rapid deployments but it has the downside of use-based pricing which makes it cost prohibitive for extended use.

Two elements are critical in order to lower the costs when satellite is used for connectivity:

- A service with an in-country hub is preferred to one where the hub is located outside of the country
- in case of rural wireless VoIP it is possible to reduce the satellite traffic by inhibiting local traffic.

Costs remain the single biggest deterrent to satellite broad-based reliance, with the service primarily serving as a backhaul where no other options are available.

Network Dimensioning is a key area and a complex task requiring attention when planning a broadband wireless access network. Technical planning, network dimensioning and definition of the service portfolio need to go hand in hand in developing a business plan for a local broadband access network. The lack of coverage and/or services delivered with a quality which fails to meet user expectations may undermine network sustainability. Network architecture and costs depend on factors and service decisions such as:

- deployment scenario and propagation environment,
- technology and frequency bands,
- marketing decisions and assumptions - served customers, planned services, service penetration and subsequent required capacity.

There is not a mainstream approach to local broadband access in the best practice cases we identified. The message is clear: technology should fit local conditions. Profiles of each case study are provided in **Annex 2**.

Table 5 – Examples of Transmission Technologies Used in Case Studies

Best Practice	Category	Features	Examples
Transmission Technology for backbone, backhaul and last mile	Wireless Broadband (Wi-Fi and WiMAX)	It can be deployed for the access and backbone networks in both licensed and license exempt frequency bands. Cell coverage and capacity depend on terrain and on LOS/NLOS conditions. Flexibility and scalability, modularity based on open standards make possible the entrance of small operators; use of IP transmission standards makes both voice and data applications possible.	Sopachuy (Bolivia); Omniglobe Huaral, Televias Huarochiri, Televias Puyhuan, Cajamarca, Rural Telecom (Peru);, BecTel, Los Botados, *La Yautia and Peralvillo, Rural Broadband Connectivity* (Dominican Republic); Ta Van (Vietnam); Allegany county, Minneapolis, Racine County (USA); Castanhal City, Pedreira City (Brazil), Djurslands (Denmark); Yachana (Ecuador) *Planeta en Linea (Guatemala)*
	2G and 3G	Mobile and fixed applications, not cost-effective for the latter, cost of a greenfield installation high, but expansion of existing second and possibly third generation systems can be cost-effective. Prices for 2G equipment and handsets have fallen dramatically.	Ruralfone (Brazil), Valtron ,, Rural Telecom (Peru), Telmex (Mexico), *The Millennium Village (Africa), Rural Broadband Connectivity (Dominican Republic)*
	Satellite	High operational costs can make it an unfeasible solution, but is still often the only possible backbone solution for many rural and remote locations	Sopachuy (Bolivia), Ta Van (Vietnam), Televias Puyhuan Project (Peru), *Banda Ancha para las Localidades Aisladas (BAS) Project (Peru)*
	Wired (ADSL, Fiber, Cable, PLC)	Economically unfeasible in rural and remote areas. PLC uses existing infrastructure.	*Castanhal City, Pedreira City (Brazil); Djurslands (Denmark), Estrela Telecom, Rural Broadband Connectivity (Dominican Republic)*

7. FUNDING

While the cost of setting up a local access network has been declining dramatically over the last decade, funding the initial investment can still be a challenge for several potential operators and it is only a first piece of the puzzle. A new venture needs capital also to cover the foreseeable gap between costs and revenues during the start up phase that may last from a few months to a few years. We review in this chapter the possible sources of funding for operators trying to set up a local access networks. These sources are not mutually exclusive and the full menu is not always available for each new venture.

Government and Donors. Public funding and donor initiatives have often proven essential for bringing connectivity to rural areas, but they also run the risk of undermining the for-profit approach which is essential for long term sustainability. Donors and governments may provide demand for the community network, representing thus a revenue source which ensures long term sustainability. A government's own activities as a user of telecommunications can lead to direct financing of major components of new networks and services, which can help expand the market and reduce risk. In thin markets, business revenues, including the highly important public institutions such as municipality, schools, libraries, police, etc. , can serve as the anchor tenant from which to enter other markets. It is unlikely that revenues from household subscribers alone can drive development of broadband in these markets.

Role of public-private partnerships. The role of public-private partnerships in the financing of community networks has been an accepted model in Europe and has emerged also in the United States and in several projects we reviewed.

Voluntary networks, where groups of people within a community work together towards providing high-speed Internet access, can be a cost effective way of delivering services at affordable prices. Since these initiatives are voluntary, the costs are normally confined to equipment, which can be fairly nominal and often funded by grants, donations or by some type of nominal user fee. In more rural and remote areas, where there is no existing broadband infrastructure, the economics become more problematic, as there are often significant costs involved in setting up the backhaul and access to the backbone. A fairly common approach is the use of satellite backhaul and local distribution provided by a Wi-Fi system. Even with voluntary labor, the initial capital costs and ongoing backhaul costs mean that monthly subscription fees well above the spending availability of low income people would be required. An opportunity for lowering cost is adopting an outsourcing model.

Carrier Expansion. There are cases where mobile operators are expanding into rural areas by making capital investments and becoming partners in the expansion of broadband networks towards rural and underserved communities.

Micro-credit. Micro-credit targeting small, medium, and micro-enterprises has been an important tool in rural development for years. Both government and multilateral development institutions can play an important role through the support of the emerging class of micro-financing institutions that serve rural and low income populations. A good example of an organization that facilitates micro-credit is the Latin American Challenge Investment Fund (LA-CIF), which partners with a variety of international lenders such as the IADB, Finland-based Finnfund, Norwegian Norfund, and Canada's Groupe Desjardins. LA-CIF provides short-term loans to

local financial institutions that offer microcredit in six Latin American countries, principally Peru and Nicaragua.[12]

Universal Access Funds or Universal Service Funds (USF/UAF) although present in many countries for decades, their use has not been as effective in narrowing the urban-rural digital divide as desired. The most progress has been achieved with the progressive liberalization of telecommunication services. Universal service funds are needed to support the "access gap," the gap that exists private sector does not seek to deploy service because of the insufficient ROI and profit margin as compared with urban markets . Ideally USF programs should operate like venture capital funds that provide the investment funds required for launching community-village level micro-telcos.

Two were the key weaknesses of the first generation of USF: 1) the subsidies typically went to the few licensed telecom operators who had little interest in rural areas unless the government paid them through the USF/UAF, and 2) the typical approach was an urban-to-rural outreach, with a common model being to put one

Box 5 – Universal Access Funds and Rural Broadband. The Case of the Dominican Republic.

An interesting example is provided by the Dominican Republic. There were two stages in the implementation of Universal Access programs of the Dominican Republic:

- Until 2006 – the priority was to bring telephone service and Indotel installed 1,700 public telephones. Most of small villages now have public phones with pre-paid cards. In addition, the Indotel CCI (Central Capitacion Informatica) Project trained the population in informatics. Almost 1,000 centers were equipped with ten computers each, a WLAN, electricity supply for some hours a day, backup power batteries, and in some places also solar power. Some of these centers are connected to the Internet.

- In 2007 Indotel started the Rural Broadband Connectivity Project to connect 508 towns with broadband and telephone at home. Many pilot projects were started before this large project. Then the Rural Broadband Connectivity Project was awarded with a public bidding. Among twenty participating companies, the project was assigned to the incumbent, Claro Codetel. The project was technologically neutral, but the incumbent, due to the networks already deployed, will use 3G technology. The project aims at providing broadband services to any segment: SMES, training institutions, schools, and private users. The end date for the project is July 2009.

Indotel, the Dominican Republic Regulator, adopted the Minimum Funding model. In the case, for example, of the Rural Broadband Connectivity Project in order to make it attractive for the private sector, the amount of money needed to make the project profitable was calculated. Based on the result, Indotel defined the maximum amount of money that could be disbursed and opened the competition to interested companies. With this mechanism, the project is awarded to the company requiring the smallest percentage of subsidy below the ceiling. The disbursement model in the case of Indotel is an immediate down-payment (usually 40%) and then a fixed amount given every month over five years. The most common case is that of a private operator who owns and runs the network (no cases of Municipal networks in the Dominican Republic). Funds are disbursed to the private operator.

[12] Peter A. Stern, David N. Townsend "New models for Universal Access to Telecommunications Services in Latin America" Regulatel.

or two phones into a rural community via microwave or satellite. The result of such an approach was a continual need for cross-subsidies and the tendency to ignore the demand for services *within* the rural community.[13]

The emerging second generation programs seek to establish a new base that is built on the widespread and successful deployment of mobile telephony by the private sector, an increased focus on the Internet, and moving beyond shared access towards individual service. Factors driving the shift are the following[14]:

- A newer generation of technologies which includes mobile technologies as well as broadband, wireless and convergent IP-based networks
- The economics of these newer technologies - they deliver more for much less.
- Need to build upon the tremendous impact that has resulted from more mature liberalized/competitive markets.

There is a growing realization that expanding these enhanced telecommunications services has a critical role to play in delivering a wide-array of socio-economic benefits to those living in these under-served rural areas.

Essential elements of the new generation of Universal Access/Service Funds[15] are:

- Access Gap—they take into account the gains for the private sector in closing the Market Gap. The focus will be on rural communities not reached via free-market dynamics.
- Focus on broadband as a core ICT component for bringing access to value-added content and services
- Community-Based Approach—the new UA/S programs look beyond placing a few pay phones in a community. Rather, they aim at the delivery of a convergent wireless network to the entire community
- Beyond Carrier-Level Competition—the new UA/S programs recognize the need for introducing the concept of single-community based carrier allowing local needs to be met where the established carriers are not providing adequate support.
- Local Business Model - with the technological solutions now available, there is a need to shift the focus from urban-to-rural to a rural-to-urban. First mile first. Community-centric Telco.
- UA/S Funds as Venture Capital—the new UA/S allows for innovative use of funds to support the initial capitalization of these small community networks.
- Voice & Internet—the new UA/S looks to build a single broadband convergent IP-based network where voice (via VoIP) and Internet can be delivered, likely through wireless.
- Shared Access and Individual Service—the new UA/S takes a hybrid approach—delivering shared-access through Telecenters but will also deliver low-cost voice services to households and businesses.
- Backbone—the new UA/S focuses on funding/building a shared backbone where the carriers can obtain broadband access at reduced costs.

[13] Darrel Owen - *Expanding Rural Access*, Associated Working Papers, January 2008
[14] Ibidem.
[15] Ibidem.

A growing number of UA/S programs are currently in transition to the new approach. Valuable Information was also provided by USAID, based on a project for the deployment of a wireless broadband local network in TaVan, Vietnam. The key focus on this project was the establishment of a new Universal Service Fund. It had just been authorized, but at the time of network implementation was not operationalized. The focus they took in the project was to:

- move away from rural phones (one or two phones for the whole community) and towards broadband
- move towards considering investments rather than just continuing cross-subsidies
- move from simply providing broadband into the community (e.g., PCs in telecenter), to broadband across the entire community - into the health clinic, the school, the private businesses, etc. It was on this last topic that they used the TaVan deployment to demonstrate to the USF how this could be done off of existing satellite-VSATs already being used in country for the one-two phone model (IPStar). This appears to have worked.

Box 6 – USF/UAF: Benefits for Governments

The government benefits in several ways from **expanding telecom into rural areas** via universal service/access funds (USF/UAF):

1. it encourages small-medium investments in areas where it is traditionally difficult to promote any form of investment.
2. it reorients the USF/UAF approach towards small community-focused loans and away from ongoing, never-ending subsidies.
3. it lowers costs and captures more revenue from consumers.

Rural economic development also serves government interests by strengthening the tax base:

1. whether a stand-alone business or a franchise from an existing carrier is created, a new business is created in the rural community.
2. it has been proven repeatedly that telecom services *by themselves* have a positive impact on local economic activity.
3. these IP-based services enhance the delivery of/access to government services via the Internet including improved health and education services at a lower cost.
4. by delivering enhanced services in a richer economic environment, telecom services have the potential for slowing rural-to-urban migration.

Source: Darrell Owen, *Expanding Rural Access*, Associated Working Papers, January 2008

Choice of financing mode in our case studies. Once again, the best practice examples reviewed in this study adopted several modes of financing as described in **Table 6** below. Full details on each are available in **Annex 2**.

Table 6 - Mapping of Financing practices and business cases

Best Practice	*Category*	*Features*	*Examples*
Financing	Foreign donors, loan guarantees, vendor financing, NGO investment funds	Financing methods characterized by the involvement of donors and financing institutions, and committed stakeholders within the local community	Huaral (Peru), Ta Van (Vietnam), Ruralfone (Brazil), Yachana (Ecuador), Televias Huarochiri (Peru), Last Mile Initiative Project (Guatemala), Sopachuy (Bolivia), Wind Telecom (Dominican Republic)
	Public Private partnerships	Accepted model in Europe and the United States. Involvement of local government for the provision of Internet services to residential business and local institutions	USA, Piraì, Tiradentes(Brazil), LMI Project (Guatemala)
	Universal Access Funds	Subsidies mechanism for the promotion of universal access	See Table in Annex 3 for details
	Financing of voluntary networks	Groups of people within a community work together towards providing high-speed Internet access, can be a cost effective way of delivering services at affordable prices	Djurslands (Denmark)

8. VALUE ADDED SERVICES

The ultimate value of a local access network for served communities is not represented by the technology in itself, but by the value added services that it delivers. These services have to meet local demand and willingness to pay. These services (e.g., voice, internet, distance learning, telemedicine) need to take into account the communities to be served, their unmet or insufficiently met needs, their ability to understand and use such services and their willingness to pay for them. All of these aspects are reviewed in this chapter.

Communities to Be Reached

Local Broadband Access Networks can serve **different communities with different services**:

- **Urban underserved areas.** Typically small and medium size towns, in addition to rural areas, are underserved in terms of broadband services, either because there is a single operator with nearby fiber that sells capacity to local ISPs (which results in high retail access prices) or because local telecom/cable operators lack incentives or resources to upgrade networks.

- **Non remote rural communities** for which the type of network depends on the size of the community, the geographic extension and the distance from existing network facilities.

- **Remote rural communities** which can be reached through a combination of broadband wireless access technologies and satellite link.

Service Offerings

Whether or not people choose to make use of services depends on:

- **Affordability** - i.e., the extent to which the price of broadband internet services represents an efficient use of the economic income
- **Ease of use** - in terms of information and communication capabilities and education required to access the service and benefit from its use
- **User value** - i.e., the extent to which broadband internet service improves the user's quality of life

A winning approach needs to include network stakeholders when defining the portfolio of services. Successful initiatives are therefore based on service offerings which, especially in the case of remote and underserved areas, have to be tailored to the economy of the communities they serve and to low-to-moderate income consumers.

Voice

In many areas, voice service is still at the top of revenue-generating service. In the Dominican Republic, Bec – Tel's WiMAX network delivers telephony (VoIP) and Internet access to a client base comprising businesses, residences, private schools, public agencies and local municipalities. Part of the service (public telephony) is subsidized by Indotel and the rest is self-sustained. The Case of Ruralfone in the State of Ceara (Brazil)

Box 7 – Serving the Market at the Bottom of the Pyramid in Brazil

The marketing choice of Local, Ruralfone's Brazilian subsidiary, is to serve the market at the bottom of the pyramid (BOP market) in an urban deployment scenario, where the average income is 1,000 US$ per capita per year. Local Telecom uses a telephone system with radio transmission in GSM technology for the Wireless Local Loop. However, due to regulatory restrictions, the terminals do not function as cellular phones. Mobile technology is used for fixed applications. The Company is technology-agnostic, providing also an example of technological neutrality. According to Ruralfone, technology needs not to be an issue, as the real focus has to be on providing affordable services, whichever the underlying technology.

Service penetration by Local had a 70% growth in 3 years with 600 minutes/month/subscriber due to simple and cheap tariffs and low termination costs (compared to an average of 70 minutes in Brazil). Local attained, in its Quixadá unit, one of the four municipal districts where currently active, the profit goal of 50% before interests, taxes, depreciation and amortizations (EBITDA) - profitability superior to that of the operators of conventional fixed telephones. This is the result, in addition to the choice of voice as a service, of the pricing policy. focused on simplicity and affordability for local population - only two very cheap and easy to understand tariff plans.

provides another interesting example documenting the value of voice services for some developing areas in the LAC region (see **Box 7**).

In those areas where penetration of mobile telephony is high, cellular service represents a strong competitor for VoIP. In these cases VoIP might not be the driver for the implementation of a broadband network.

Public Services

When defining deliverable services, aggregation of both public and private broadband access demand can create strong incentives for investment, particularly in more remote and under-served areas.

Local governments often tend to be among the customers for Internet access services. Priorities in public services include delivering education and training over the Internet and health related services. These services can be delivered through a telecenter. Other dynamics taking place with significant potential impact are those of lower-cost telemedicine solutions supported by local broadband with the support of partnerships and business models previously described. Where allowed by the regulation, a rural telecenter is the ideal place for delivering services off of a banking platform linked to financial institutions. Other business oriented content and services holding potential for adding value include e-commerce for expanding exports to international markets and for-fee commercial information.

The Yachana project described in **Annex 2** is an example of how a high school, an ecotourism lodge, a medical clinic and a bioscience center all benefit from being connected to a wireless broadband network.

Local End User Content

The opportunity of developing local content and service augments the broader services that are provided from a national network.

Focused marketing with pricing strategies also based on community needs is important in the provision of services through local networks. It is easier to adopt this approach when the company is based in the community and when staff is locally hired. The business cases of Ruralfone Brazil and the Huarochiri project in Peru in **Annex 2** are interesting examples of similar marketing practices.

CPE Subsidization

Each operator must evaluate whether to include in its offer free or subsidized customer premises equipment (CPE). CPE is a critical variable which may affect project sustainability. In most cases reviewed by our team there are no examples of CPE subsidization. One of the lessons learned at Bec-Tel's, Dominican Republic, from the commercial Deployment of its WiMAX network, is that the high costs of CPEs tend to limit a project's growth. On top of the CIF price, local telecoms must pay duties, excise and value-added taxes that could reach 61%. Consumers must pay 28% in taxes when they buy the equipment. In the case of Bec Tel, CPE's are not subsidized to the customers, but financed over a period of 18 to 20 months, which is the typical duration of a contract.

In Peru, due to the poverty level, PCs and CPEs in general are the most critical complementary asset. It is important to notice that when you're trying to drive internet to the households, the complementary asset represented by PCs are often too expensive. In less affluent rural areas a very good model is a telecenter rather than broadband to the home.

Box 8 – Value Added Services: Recommendations

The following actions with respect to partnership and commercial arrangements are recommended:

- Involve local communities in the definition of service to be delivered and then, in network managements and operation
- Market services that are targeted to the local population
- Services have to be planned in accordance with possible local, national and regulatory issues (e.g. licensing requirements).
- When compliant with regulation and licensing requirements, applications such as VoIP should be supported by the network, as they enable provision of a valuable service at a fraction of the investment needed to build and maintain a traditional telephone network.
- Evaluate the opportunity for supporting, in addition to residential and business services, institutional services (internal connectivity, e-government, public safety applications)
- Involve in the definition of services and training also NGOs and Institutions committed to the local community's economic and social development, although in different sectors (e.g. agriculture, commerce). Economic development for rural areas requires not only the deployment of ICT, but also an eco-system of key actors (NGOs, private associations, Universities, Institutions, and Local Governments).

9. BUSINESS MODEL

At the core of the long term sustainability of local access networks is the choice of the correct business model. This model must combine the technological, funding and service choices described in the previous chapters into a coherent structure: a public network with free access to all or restricted access for the public sector alone; a telecenter where users need to go to a specific location to access the network or a micro or nano telco which resembles telecom operators except for the much smaller clientele is serves. All of these models and their individual features are reviewed in this chapter.

There are **four business models** used for local broadband access networks:

- the **public network model**, where all investments and operating costs are borne by local authorities (e.g., municipality, district, province, region, state) with or without private sponsors. Access can be either (a) limited to public institutions (including hospitals, libraries and schools) where citizens can use broadband services for e-government or any broadband service, depending on the network's policy; or (b) offered anywhere to anyone for free (e.g., Muniwireless - see **Box 12**);

- the **telecenter model**, where users have to go to an Internet Cafe or similar location to access the Internet through one or more computers. The telecenter was the first business model to introduce broadband connectivity in rural communities. Perhaps the most stylized model of a telecenter is a location within a community that contains a number of computers that are connected to the Internet. Telecenters have been the first broadband providers to emerge for several reasons. First, getting broadband access to one location (the Telecenter) has been possible in several areas of the developing world for a relatively long time. Second, many Internet users cannot afford computers but can pay reasonable Telecenter fees. Their success, however, especially when sponsored by donors, has been fairly limited.

- Local broadband access networks are often built and operated by **micro-telcos**, "small-scale telecom operators that combine local entrepreneurship, innovative business models, and low-cost technologies to offer an array of ICT services in areas of little interest to traditional operators". Microtelcos typically have between 200 and several thousands of subscribers in communities with more than 10,000 inhabitants. Since the regulatory reforms undertaken in many countries of the LAC region during the 1990s, it is apparent that the provision of ICT services is no longer limited to large operators – be they public or private. A variety of small-scale market entrants including cooperatives, municipal governments, community organizations, universities and local entrepreneurs participate in the deployment and operation of public ICT networks. This is perhaps most noticeable in areas unattractive to large operators, where a variety of unorthodox arrangements exist to serve high-cost or low-income communities.[16]

[16] Hernan Galperin and Francois Bar, *The Microtelco Opportunity: Evidence from Latin America*, 2007, p. 3.

- Smaller communities – with less than 10,000 inhabitants and a potential subscriber pool between 50 and 200 users – are served by **nano-telcos**. The main difference is technological. While micro-telcos can often afford WiMAX, nano-telcos use point-to-multipoint Wi-Fi or Wi-Fi-mesh. According to the information collected during the visit to Guatemala particularly in cases where WiMax is the technology selected for a mass deployment (i.e. using WiMax to reach retail customers), an appropriate market size is required – usually around 400+ subscribers to make the project viable. Therefore, for areas with populations of fewer than 12,000, other technologies such as Wi-Fi ought to be considered. WiMAX can still be used in a point-to-point configuration to feed the Wi-Fi network through backhauls. This holds true until prices for WiMax equipment is significantly reduced or alternative mechanisms of financing become available.

Today barriers faced by Micro- and Nano-telcos can take many forms: regulatory (licensing, spectrum availability, quality requirements, etc), financial and even human resources. Lifting regulatory barriers is necessary but probably not enough. Many potential entrants or existing small operators in fact lack the financial and other resources necessary to enter the market. Telecom development funds and Public- Private Partnerships are vital in this respect.

Successful business models have several core features described below.

Local Stakeholders involvement. A successful project will involve stakeholders as early as possible. Stakeholders typically include representatives from the local community and institutions, government (local, regional, and even national, depending on the project), technology partners, and funders. According to our interviewees, it is extremely important to involve key stakeholders who can guarantee good relationships with Government and sector Ministries and access to relevant officials. According to our interviewees), trust has emerged as a very important issue for communities in rural areas of Peru, where often entrepreneurs coming from the outside (even from Lima) are *not welcome.* Many social issues have to be considered, as sometimes residents do not protect the antennas unless they belong to the community. For this reason it is mandatory to identify a trusted local leader.

Strategies for community involvement are discussed in **Box 9** below.

Box 9 – A Strategy for Community Involvement

An effective strategy in gaining community support may work as follows: (i) identify those stakeholders who have the trust of the community and are most interested in the project (ii) involve them as advisors or members of a steering committee ; and, last but not least, (iii) understand community needs before introducing a technology.

This final task requires an in-depth knowledge of the community and its institutions: focus groups are required to define needs, applications, and performance metrics. It is important to avoid building unwarranted enthusiasm and expectations in terms of quality and price around network services. Uses and applications have to be prioritized. Local stakeholders should also take responsibility for long-term sustainability.

Once a broadband network is in operation, local communities have still to be involved in dissemination and training sessions in order to build confidence and promote service adoption. Especially in remote and poorer areas, users need to build confidence in new resources before they consider them a real opportunity.

User capabilities are crucial, particularly as far as internet is concerned. They include the ability to access resources in ways which suit people's needs and offer them real worth. There is evidence that this has inhibited internet adoption in many communities.

Local ICT and Management Capabilities. ICT skills and the ability to run an enterprise or a project are one of the most critical elements at the local level. There is also a need to expand ICT-related knowledge and skills at the policy and strategic levels of government, within the business community, and throughout the formal education system, as well as building the technical-product related skills essential for supporting infrastructure deployment and operations.

Local broadband networks, once available, may boost local entrepreneurship. In the Dominican Republic, the Los Botados project was originally born as a pilot project envisioned by Indotel to test the feasibility of providing a small community with broadband access. In this project, the local municipality provides electricity and secures the equipment, while Viva (formerly Centennial) is responsible for providing network maintenance and operations. The network is open and people from the community connect using PC's. Some entrepreneurial activities have emerged as a consequence: PC's assembling and Internet/computer training classes, among others.

Private sector involvement. One of the main weaknesses of several ICT programs in underserved areas was the minimal role of the private sector in running them. Strong private sector commitment is key. In many successful local broadband access networks, public resources have been start-up funds for a sustainable for-profit business development. Public/private partnerships are emerging as a very important factor in the deployment of local municipal networks. Often international high-tech companies seek entry into emerging markets. As a consequence, there are opportunities for the public sector to partner with these private firms. Partnership arrangements can take a variety of shapes and forms and can go from the private sector financing the network, operating the network, or both financing and operating the network on behalf of the local government. Multinationals like Intel and Cisco, for example, are sponsoring local access broadband networks in Brazil and other countries through the provision of free equipment and technical assistance.

Most often, local governments bring availability of assets (poles, buildings) where network equipment can be installed, or existing facilities (e.g., fiber) for interconnection. In many cases local governments and municipalities are also anchor tenants for the network and benefit from it in several ways as discussed in **Box 10** below.

Box 10 – The Public-Private Partnership Model

The InfoDev "Study On Local Open Access Networks For Communities and Municipalities" shows that these partnership models are particularly advantageous in situations where the public component (usually a municipality) has limited or no expertise in operating networks, and/or there are restrictions on the provision of retail telecommunications services. Local Governments partnering with local institutions can deliver really valuable services to the community.

Public/private partnerships are quite common in the USA and they may be adopted for local network deployments in other regions.

The primary drivers for municipal and local governments to enter into the various forms of partnerships for developing local access networks are:

- Lower the cost of providing municipal services
- Increase government efficiency and productivity by providing local information and online services
- Promote local economic development and competitiveness, by providing tourist information or pricing and market information to local businesses.
- Address social development and inclusion by delivering education over the Internet
- Increase in the affordability of computers through volume discounts and tax incentives
- Improve the availability and affordability of broadband Internet services.

Sustainable local broadband access networks call for business models which present a win-win situation for all players. According to one of our interviewees, whereas the public utilities in the past financed, built and operated the entire network, municipal ICT projects today are more likely characterized by innovative models involving the private sector, Customer Based Organizations (CBOs) and other organizations (often educational institutions). Municipal network projects aim at facilitating investments in underserved areas rather than competing with existing operators. As one of the largest users of ICT services in the community, local governments benefit from financing and managing their own infrastructure where private operators fail to invest properly.

Government is often the largest local buyer of ICT services and contributes to the building of local capabilities. A possible path for a municipal network involves two steps:

- the network emerges from the need to equip local government offices and public entities (schools, libraries, police stations, health clinics) with ICT access; and
- the network introduces broader initiatives serving local businesses and residents.

Local Franchise of Existing Carrier. Too often telecenters and other specific project did not have the volumes needed to achieve economies of scale and therefore sustainability. The franchising mechanism is a viable approach for the establishment, management, and operations of a rural community-based network. Here, a group of investors, a mobile operator, or a telecom carrier provides the required investment capital, interconnection, technical expertise, and training. The local franchisee provides day-to-day operation under the licensing and management of an existing carrier.

The need for a comprehensive and realistic Business Plan. To ensure network sustainability over time, there is need to develop a comprehensive business plan, including detailed and realistic assumptions on service adoption rate, service pricing and realistic financial projections. According to our interviewees, a key success factor lies also in keeping costs low**.** Failures in rural areas are often due to over-investment. This is particularly true when donors and/or governments are directly involved.

Box 11 – High Priority Actions towards the Definition of a Business Model

The following actions with respect to partnership and commercial arrangements are recommended:

- Project manager, technical personnel, and others involved in the network project have to explain the concepts and the benefits of implementing a local broadband access networks to participating local institutions, organizations and community leaders from the start.
- The initiative needs to have a clearly defined and formal organization structure. In addition, local organizations need to get local entrepreneur who will run the network and future users involved directly in the planning of the network and services in order to build managerial skills and create awareness of how these instruments can enhance users' lives.
- Public sector may need to take an equity role in the network, especially in areas where the access gap is due to sustainability issues. This is most commonly due to lack of sufficient population density in semi-rural and rural areas.
- Encourage the role of local entrepreneurship in the various organizational arrangements
- Business model and partnerships have to be designed taking into account possible restrictions imposed by legislation on the role of each partner
- Clearly defined conditions and requirements imposed on operators and service provider, including quality of service obligations, interconnection agreements and the set of licenses required to provide planned services
- The local community organizations involved, including local governments, schools, hospitals, agricultural and other associations have to commit to sharing costs either through a specific budget item or a user fee. In most cases, the additional budgetary requirements will be offset by savings resulting from the project in communications and travel.

Distinct business models have to be analyzed based on each model's ability to meet the defined objectives. These are considered distinctive features of the possible business models and partnerships

- They clearly define what each player is bringing to the table
- They clearly define the role of all possible players (municipality, local authorities, NGOs, funding institutions, network operator and service provider) in network building, ownership, operation and maintenance
- They take into consideration possible local, national and regulatory issues which may have an impact on partnership arrangements and business models
- Present a win-win situation for all players involved

Box 12 – Lessons Learned from Muniwireless in the United States: weaknesses

Recent experience of municipal wireless networks in the United States is instructive in reaching conclusions regarding sustainable broadband projects.

A case in point would be Earthlink's municipal projects. Although Earthlink devoted about US$200 million to the deployment of networks in Philadelphia, San Francisco, Houston, New Orleans and other metro areas, they ultimately pulled out of the market due to a failed business model.

Key reasons for this failure include the following:

- Residential public access was the main source of revenue. In areas with high DSL and cable penetration this is a low margin hyper competitive market where Wi-Fi could not compete. The quality of service issues that are inherent with Wi-Fi mesh networks made it a challenge for Earthlink to gain market share.
- Financial benchmarks were too optimistic:
    - Residential penetration rate of 22 percent by EOY 4: Less than 10 percent is a more realistic number based on experience of other service providers.
    - Node density count of 37 radios per square mile: Actual deployment figures are 45-60
    - Subscriber acquisition cost of $115: Clearwire's acquisition costs are $300-$450 for residential access.
- Underestimation of time required to get access to mounting assets
- Lack of focus on higher value customers: businesses, educational institutions

Since Earthlink's departure from the municipal wireless space in September 2007, other service providers have followed: Kite Networks, MetroFi and Azulstar to name a few. They all experience the same pitfalls as Earthlink, though there were a few additional factors that attributed to their demise that have plagued many of the failed muniWiFi projects:

- Unrealistic coverage requirements
    - Municipalities required that the ISP cover parts of the community that did not support the business case, i.e., vacant areas with no potential customers
    - Municipalities had network availability requirements that rivaled or even surpassed cellular standards
- No financial commitments from the municipality or other project stakeholders
- Expectation of free municipal service and some free residential service
- Lack of requirements regarding client devices that will be used on the network. For example, networks were designed for laptops with an external modem, but the majority of users have iPhones.
- Lack of knowledge regarding ownership of mounting assets
- Focus on soft cost savings(productivity, economic development, Digital Inclusion) and not hard cost savings (automated meter reading, fuel cost reduction, leased line replacement)

Other practices. Possible other business practices and areas needing attention are:

Outsourcing and demand aggregation. Small local companies often do not operate at volumes which allow them low costs of connectivity (whether for local network equipment or for connectivity to the backbone network). Some companies offer outsourcing for equipment, design, Internet connectivity and demand aggregation. The advantages include lower connectivity prices, easier regulatory compliance, simpler administration, and reduced financial risk.

The role of the NGOs. NGOs can play an important role in the diffusion of local broadband networks. The main reason is that NGOs themselves generally need affordable communication systems and recognize the central role of these systems for other development objectives. NGOs, with their fundamental role in sponsoring community-based development initiatives, can contribute indirectly to local broadband access networks financing by supporting micro-financing activities. In most of the business cases we reviewed, NGOs have proven fundamental in establishing good relations with local Institutions.

Network management. In a number of local access networks deployments, decision making on several issues has been delegated to locally hired staff.

Box 13 – Lessons Learned From Muniwireless in the United States: success factors

Cities that are seeing success with their projects are finding that the following parameters are playing a role in their success:

- Financial commitments from the municipality and/or other stakeholders
- Clear path to profitability for the service provider
- Municipal ownership of network infrastructure with an ISP acting as the operator
- Limited strategic deployments for public access: downtown areas, parks, universities
- Universities are playing the role of anchor tenants
- Focus on municipal applications: meter reading, mobile public safety, work order management, video surveillance, etc.
- Deploying hybrid networks that involve Wi-Fi and WiMAX, TD-CDMA, and other technologies

Features of the business model in our case studies

Most projects we reviewed combined several of the elements discussed in this section. **Table 7** below presents an overview, while **Annex 2** contains details on each of the examples mentioned in the table.

Table 7 - Mapping of business model's features and business cases

Best Practice	*Category*	*Features*	*Examples*
Business Model's Features	Local communities Involvement	Identification of stakeholders, community involvement in identifying needs and defining delivered services, in dissemination and training sessions in order to build confidence and promote service adoption, definition of local stakeholders should also take responsibilities for long-term sustainability	Allegany county (USA), Chancay-Huaral (Peru), Wireless Minneapolis (USA), Racine County (USA), Valtron, Rural Telecom (Peru), (Planeta en Linea Guatemala),
	Microtelcos (in the various organizational arrangements including municipal initiatives)	Small-scale telecom operators combining local entrepreneurship, innovative business models, and low-cost technologies to offer telecommunications services to areas of little or no interest to traditional operators. Better knowledge of community and its needs. Municipalities are often key partners, allowing to take advantage of municipal infrastructure	Huaral Project (Peru), Piraì (Brazil), Sopachuy (Bolivia), Djurslands (Denmark), Televias Puyhuan, Televias Huarochiri (Peru), Last Mile Initiative Project (Guatemala)
	Public-Private partnership	Emerging as a much more important factor in the deployment of local municipal networks. Variety of shapes and forms from financing the network, operating the network, or both financing and operating the network on behalf of the local government.	Pedreira City, Piraì, Tiradentes, (Brazil), Los Botados (Dominican Republic), Wireless Minneapolis (USA)
	Tailored Services and Marketing	Offering tailored on community economy and needs: services, pricing, evaluation of the opportunity to offer and/or subsidize customer equipment	Ruralfone (Brazil), Huarochiri Project (Peru), Valtron, Rural Telecom (Peru, Planeta en Linea (Guatemala), CCI Project (Dominican Republic)
	Local Network Management	Decision making is left at some extent to the locally hired staff. A very important adopted policy in cooperative and commercial community projects is to give to young people in the community the responsibility for managing and operating the network	Chancay – Huaral (Peru), Ruralfone (Brazil), Televias Puyhuan (Peru), Valtron, Rural Telecom (Peru), CCI Project (Dominican Republic)
	Outsourcing, demand aggregation, and franchising	Outsourcing, demand aggregation, and franchising may result in significant savings in capital investment during the design, implementation and operation phases of local broadband access networks	Ruralfone (Brazil), Planeta en Linea (Guatemala)

10. COUNTRY CASE STUDIES

The above framework and lessons emerging from the desk review were applied to four countries: Brazil, Dominican Republic, Guatemala and Peru. These four countries were selected because of: (a) their different size and geography; (b) presence of a sufficient number of local broadband access networks or projects identified during the desk review; and (c) widest representation of the different sub-regions (South America, Central America and the Caribbean). All four countries were visited by a team of two international consultants supported by one local consultant. Their main findings are presented below.

Building blocks for productive broadband access

Table 8 below summarizes the main findings of the country case studies on the enabling environment for broadband, the level of ICT access, and the affordability and quality of broadband.

Table 8 – Enabling Environment ICT Levels, Affordability and Quality of Broadband (Brazil, Dominican Republic, Guatemala and Peru)

Country	*Enabling Environment*				*ICT Level*			*Affordability*	*Quality*
	Rural Access Index	Ease of Doing Business (1 highest; 181 lowest)	Government Prioritization of ICT (scale 1-7)	Quality of Broadband Access Regulation	% of households with computer	% of households with Internet	Broadband Penetration (Fixed + Mobile)	Price of Broadband (as a % of GNI per capita)	International Internet Bandwidth per Internet user (bit/s)
Brazil	53%	125	4.4	Medium	20.8	15.4	4.7	9.6	2,955
Dominican Republic	62%	97	3.4	High	12.5	5.7	1.6	9.5	894
Guatemala	55%	112	3.3	Low	13.6	1.8	0.9	16.7	1,429
Peru	43%	62	2.8	High	13.8	5.6	2.0	12.7	9,877
LAC	59%	40	3.5		19.1	8.8	4.6	14.0	8,089
Source	WB	WB	WEF	Team	ITU	ITU	ITU	ITU	ITU

The most favorable combination is present in Brazil and the least favorable in Guatemala. The Dominican Republic and Peru are in between these two extremes.

Brazil has a general business environment which is certainly not enabling and a low access to infrastructure in rural areas. These factors do not affect the sustainability of broadband local access networks but could minimize their impact on economic development. The level of ICT penetration is higher than the Latin American average: three out of four households with a computer have internet access and broadband access is one of the most affordable in the region. Quantity of international bandwidth per user is relatively low.

The regulatory environment is one of the most favorable of Latin America. The entire provision of telecom services is simply linked to a concession for fixed services or an authorization for mobile and IP services from ANATEL. The National Telecommunications Agency (ANATEL) is one Brazilian regulatory agency,

administratively independent and financially autonomous, not hierarchically subordinate to any part of the Brazilian government. Municipalities have recently been allowed to provide services directly. The 2.4 GHz and 5.8 GHz frequency bands are license-exempt in Brazil. There are additional frequencies that are also license-exempt, such as 450MHz and 900MHz. The frequency bands available for WiMAX deployment in Brazil so far are: 2.6 GHz, 3.5 GHz, 5 GHz, and 10.5 GHz. Most deployments should occur in the range of 3.5 GHz. Five companies have received licenses for the 3.5 GHz and four for the 10.5 GHz frequencies. There are no regulations that pose a constraint on the use of WiMAX as a backhaul technology. Finally, regulations allow great flexibility in quality of services requirements. In fact, small local operators are almost never penalized for noncompliance with these rules.

The Universal Service Fund of Telecommunications Services (FUST) was established by Law 9998 of 17 August 2000 to finance the deployment of services of telecommunications – especially for those most needy – who would not normally provided by private companies on grounds of cost and low returns. FUST is funded through a monthly charge of 1% of gross operating revenue of providers of telecommunications services. Unfortunately, due to regulatory limitations , FUST has raised so far over 7 billion Brazilian real (US$ 3.2 billion) and disbursed less than 1 million real (0.5 US$ million). There is a draft bill under examination by Parliament that will simplify access to FUST and expand its scope to include private services (mobile, internet) within the activities FUST can support. Even if the new law were approved in 2009, it is unlikely it will have any visible impact till 2010 or beyond (as the law will require the amendment of FUST's regulations and Anatel, the telecom regulator managing FUST, usually needs more than one year to approve any project.

The **Dominican Republic** has a difficult business environment and the worst access to infrastructure by rural population among the four countries we analyzed while power outages are a constant problem. Penetration of computers, internet access and broadband is limited, even though broadband prices are among the most affordable in the region, thanks to increased competition in the provision of international bandwidth. The average bandwidth per user is low, not surprising for an island, even though such limited quality is counterbalanced by relatively low prices.

The telecommunications market was liberalized starting with the beginning of 1990s. Major regulatory reforms which took place in 1998 led to a modern regulatory regime with the establishment of the Instituto Dominicano de las Telecomunicaciones (Indotel). For ten years the telecommunications sector took advantage of those reforms, with a double digit growth of investments in mobile networks and a very positive growth in the participation of the telecom sector over GDP. According to the law, a concession is needed to provide a telecommunication service to a third party. Wi-Fi bandwidths are license-exempt and are not limited to indoor deployments. For WiMAX, the current regulation requires a license for use of the spectrum, but does not pose any kind of constraints on its use as a backhaul technology.

Regulations do not impose restrictions on the services delivered by a telecom operator which can include VoIP. The only requirement to provide VoIP services is the possession of a spectrum license (if the service uses licensed bands) and a concession. There are no restrictions to bundling of Internet service and VoIP from a single provider.

There is a Universal Service Fund (Fondo para el Desarrollo de las Telecomunicaciones-FDT) funded through a 2% tax on telecom revenues. The most important project sponsored by the FDT is the development of the

Informatics Training Centers (Centros de Capacitación en Informática -CCI). So far the project has funded the deployment of 834 centers to provide Internet access and train people of rural communities on the use of computers. The most recent universal access initiative is the Rural Connectivity Program. The aim of the project is to bring telephony and Internet connectivity to people living in rural areas of the DR. Codetel intends to use a combination of UMTS, ADSL, Wi-Fi and WiMAX to complete the project. Claro, Codetel's mobile arm, has a license for 800MHz CDMA and 1900MHz GSM, enabling the offer wireless service over its mobile networks.

Peru has better regulations than the Dominican Republic. The overall business environment and ICT regulatory framework are in fact among the best in the region. Penetration of computer, internet and broadband are instead relatively low, while the quality of international bandwidth is high but its price is also higher than in Brazil and the Dominican Republic.

In 1994 a landmark telecommunications law established a new national regulatory agency for the sector, OSIPTEL, while assigning the Ministry of Transport and Communications (MTC) the power to grant concessions and licenses, to approve the national telecommunications plans, and, in some cases, to regulate equipment standards. The law also created a rural telecommunications fund, the Peruvian Fund for Investment in Telecommunications, FITEL. OSIPTEL, the Peruvian Supervising Agency for Telecommunications Private Sector Investment, was created to assure free competition during and after the privatization of the telecommunications network.

The 2.4 GHz, 5.2 GHz and 5.4 GHz frequencies are license-exempt. There are no restrictions from Regulation to bundling of internet services and other services (e.g. VoIP) from a single provider. Different services (voice and Internet) can be bundled under the same license. Companies, with the exception of Telefonica, are not enforced to bring service into rural areas. The Peruvian legislator has adopted a law requiring that infrastructure using public rights of way be shared. The aim is to encourage electricity companies building transmission lines, for example, to allow telecommunications companies to use these lines (subject to reasonable commercial arrangements). The price would be a fraction of the cost of building single-use infrastructure. This law creates incentives for constructing a backbone. In 2004, OSIPTEL allowed asymmetric interconnection and tariff arrangements between the rural operators and others. This enables rural operators to pay less to terminate their outgoing calls on the networks of larger (fixed line and cellular) operators and to charge more to terminate incoming calls from those operators on their own networks.

Peru's Fondo de Inversión en Telecomunicaciones (FITEL) was created in 1993 and until recently administered by OSIPTEL. Since 2006, FITEL is legally separate from OSIPTEL, has its own manager and personnel, and is reporting directly to the MTC. The objective of FITEL is to achieve Universal Access to a defined set of essential telecommunications services throughout the country and particularly to the inhabitants of small towns and villages across the country with populations less than 3,000. The fund is financed by a levy of 1 percent on the gross revenues of all operators to finance universal access programs, and also a percentage of the income from spectrum auctions and funds donated from the Government (an amount of almost US$ 10 million/year goes into the found). The fund started collecting the 1% revenues from operators in 1994. The fund was originally conceived to bring telephone service closer to Peru's poorest and most isolated areas, where people still had to travel 56 kilometers on average to reach a pay phone, by offering subsidies to attract private operators' investment. Since the start of FITEL, public payphones have been installed in 6,000 small towns and US$ 160

million out of US$ 180 million have been granted. FITEL awards the implementation of telecommunications projects to the private sector through a public and competitive tendering process for all projects where the financing amount is above USD 1 million. As is the case with many Universal Access and Service Funds (UASFs), FITEL awards funded projects through a bidding process.

FITEL has designed a project called "Provision of voice and data services through broadband for rural localities in Peru - broadband in isolated localities" ("Provisión del Servicio de Datos y Voz en Banda Ancha para Localidades Rurales del Perú - Banda Ancha para Localidades Aisladas - BAS", BAS). The Project, developed by FITEL, will benefit more than one million 658 thousand habitants in 3,852 remote rural locations nationwide: 3,010 with public phones, 497 locations with fixed telephony, and 1,019 with Internet access. In 2007, Rural Telecom was awarded funds from FITEL for the Rural Broadband Project (Banda Ancha Rural, BAR in Spanish). The BAR project has the objective to deploy broadband Internet via wireless and public phones in 3010 rural communities.

The lack of terrestrial fiber-optic cables in Peru's interior represents one of the biggest challenges in developing rural telecommunications. FITEL has designed programs for expanding the backbone which involve Electric Power Supply companies for the use of their infrastructure and dark fiber. The strategy consists in extending the reach of fiber from the backbone towards villages to 200 km from the actual 80 km. Wireless (Wi-Fi and/or WiMAX) will be used to bring broadband connectivity to villages. As in Peru some communities are too far from the electric power lines, to be reached with fiber optic, VSAT would be used for those cases, but satellite connectivity is considered as the last option given the costs and the quality of connectivity. Benefits expected from the expansion of the fiber optic backbone will not affect only the rural areas but several cities as well. In Peru there are still cities (out of the main ones which are Puerto Maldonado and Iquitos) which are State capitals and are still lacking broadband connectivity. The only coverage that they have is satellite. Iquitos, the capital of Loreto is among the state capitals still lacking the broadband connectivity.

Guatemala has the least favorable environment among the four countries. Limited access to infrastructure in rural areas is combined with a difficult business environment. Computer, internet and broadband penetration is one of the lowest in the region, while the price of broadband is the highest and its quality one of the lowest.

The regulatory environment in the ICT sector is one of the most liberalized in Latin America and the Caribbean. In line with the trends of the 1990's in Latin America, Guatemala liberalized its telecommunication sector in the 1996 beginning with the privatization of the state-owned telecom company Guatel being sold to Telmex. With this effort and likely the most ambitiously open regulatory environment in the region, Guatemala saw a large influx of investment and growth of its telecommunication sector. Guatemala provides a good example of the more diversified live deployment of broadband technologies in the Central American region. Largely driven by its highly liberalized regulatory environment, Guatemala has deployed every major technology in both urban and rural environments.

There is no Universal Service Fund (USF) in Guatemala. Universal access is pursued through FONDETEL, an organization that is part of the Ministry of Infrastructure and Housing. Its focus is primarily rural telephony and its vision has not evolved to include broadband Internet. A telecommunications operator license in Guatemala does not require an investment in rural areas either as a condition of the license or leveraged through a USF. FONDETEL's only source for public investment are those assigned through the national budget and funds

acquired through the auction of the radio spectrum, an activity that is managed by the telecom regulator. This means that rather than having a constant stream of income from a USF tariff assessed to telecommunications as can be construed as common or best practice, Guatemala's only source for public investment in telecommunications is limited to a source that is only replenished every 15 years – the duration of frequency licensing agreements.

In Guatemala, a license to use a frequency is essentially a property right, with the freedom to use the spectrum as one has planned, subject only to technical restrictions that are included in the title document. The open regulation has created some hindrances to the deployment of rural telecommunications. In the concession of the radio spectrum, the assumption was that those who were awarded the concession, as custodians of the frequency and in response to market demand, would sub-license the frequency at market value to those who wished to make use of it in market spaces where the concessioner did not have a commercial interest. However, this presupposes adherence to rule of law, contracts honored, and a swift and fair recourse when needing of the judicial system. This unfortunately is not the case in Guatemala, and therefore the secondary market that was expected, did not develop, thereby creating 15 year natural monopolies across the radio spectrum.

This situation is further aggravated by frequency concessions being granted country-wide, rather than by sectors or regions, a practice that has only recently changed since they are much fewer frequencies available for tender. What has tended to occur is that much of the licensed spectrum is in use in Guatemala City, but abandoned and unavailable in rural areas.

Adding another level of complexity, the Superintendence of Telecommunication, when first auctioning off the spectrum, did not reserve what have traditionally been open radio frequencies for the use of cordless phones, garage door openers, and most notably Wi-Fi – 2.4GHz and 5.8GHz. These were auctioned to a telecom conglomerate of the financial sector that used, primarily 2.4GHz to route ATM Machine traffic within Guatemala City. It is possible to use Wi-Fi, or any other technology for that matter, for personal use within the confines of one's property, so long as it does not interfere with services the TUF holder operates. There is of course pirated use of these frequencies by registered and unregistered operators, but it was not until 2006 when the process of migrating the rightful concessioners of the frequencies to neighboring frequencies of the spectrum in a buy-back strategy to open up 2.4GHz and 5.8GHz to the public.

Local Broadband Access Networks in the four countries and Lessons Learnt

55 local broadband access networks were identified during the country visits. The number of projects is directly related to the enabling environment in each country as Brazil, which has the best overall environment, has 36 projects, Peru 10, the Dominican Republic 7 and Guatemala 2. A complete list with some details on each initiative is included in **Annex 3**.

The following are the main findings and lessons learnt.

The future is wireless. The market liberalization and the mass market adoption of wireless services since the 1990s have led to falling network equipment and handset costs. The introduction of prepaid cellular plans has eliminated the telecommunications access barrier for people at the lowest income levels. Due to these market dynamics, the cellular market in the four countries has seen among the highest rates of penetration per capita

in Latin America to date and voice is an extremely valued service for the populations living in rural areas. According to Telefónica del Perú, the country had the fastest growth rate of broadband Internet connections in Latin America in 2005: 129%, to reach 400,000 accounts. However it is estimated that still 70% of Internet users in Peru access the Internet through telecenters and only 10% of broadband users are SMEs with the rest mostly being domestic users.
In Brazil, although many political barriers in the licensing and public auctions of WiMAX frequencies still exist, wireless technologies such as Hyperlan, Wi-Fi, Wi-Fi Mesh and WiMAX have enjoyed wide adoption in the implementation of economically feasible solutions for broadband Internet connectivity. The same is true for Guatemala, though a too open regulatory environment has led to a monopolistic spectrum environment, The challenge with many of these projects is the lack of backbone capacity, which is almost always addressed by plans for deploying fiber optic or VSAT connectivity in the short term. Unfortunately it is the limited bandwidth of VSAT that in many cases is limiting connectivity at telecenters to a bandwidth that barely can be considered broadband (200 Kbps or slightly faster).

Business Model. There's a growing awareness of the need for a strong involvement of the private sector. With the exception of Guatemala, where deployment of broadband is not supported by any universal service program, universal funds have evolved from the role of government subsidy towards encouraging the market and creating incentives for private provision of services on a commercial basis. In almost all of the identified projects in Peru and the Dominican Republic, the network is owned by a private company that was awarded universal funds. In order to ensure long term sustainability, the commitment of local small entrepreneurs targeted by training for the building of entrepreneurial capabilities is an integral requirement of universal service programs.

In accordance with the data provided by Telefonica del Peru, a telecenter owned and managed by a small local entrepreneur is an ideal model for offering Internet access to lower income users. Entrepreneurs from unserved or underserved areas are willing to contribute with their own investments but they may perceive the lack of basic infrastructure such as electricity as a major threat to the profitability of their initiative.

Municipalities are on the cusp of active participation in the construction and use of local broadband access networks. This was especially evident in Brazil, and there are signs that municipalities in Peru are not far behind. Municipal participation in broadband projects should be encouraged since the enhanced services as well as the cost savings that can be attained by such applications as meter reading and online document management as well as the greater sense of security that can be delivered through video surveillance are project drivers that will encourage municipalities to embrace broadband technology in Latin America as they have in the United States and Europe.

Stakeholders' involvement. One element was common in the implementation of all local broadband initiatives we identified: the simultaneous involvement of an eco-system of stakeholders (e.g., NGOs, private associations, universities, Chambers of Commerce, local governments) committed to training of final users and community development.

Development and not a simple geographic extension of broadband, is considered as the final objective by most of the projects and funded programs. Providing better education over the Internet, supporting SMEs in

gaining the access to broader markets for local goods and in consolidating a sustainable value chain, the extension of central and regional government services, telemedicine and connection of remote health posts were perceived everywhere as value added services with the potential to make a huge difference in the life of the community.

11. CONCLUSIONS

Enabling environment

Universal Access Programs and Funds

Shifting the focus from payphones to broadband enabled services to local communities. Most universal access/service funds were originally designed to deploy public payphones in rural areas and have, in some countries, widened their scope to the provision of Internet access. Now the need is the deployment of broadband to support the access to value added content and services and to expand socioeconomic opportunities. The focus of the universal access programs should shift from Internet access (e.g., through a telecenter) towards bringing broadband-enabled services to local communities and institutions (health clinics, schools, government offices).

The backbone component. Universal funds have to focus on building backbone capacity. With few exceptions, the lack of backbone infrastructure is the real bottleneck to the expansion of commercially-viable broadband networks into rural areas and into the interior of many countries in the region. This is especially true for those programs to deliver bandwidth-intensive applications and integrated voice-data IP services.

The connectivity component. Focus of the USF programs should move from pure connectivity to the benefits delivered to the local population. The risk involved in considering connectivity as the focus of the project is to deploy sophisticated technologies that beneficiaries are not able to operate or do not value because they do not deliver relevant content. Technology and infrastructure are only project enablers. Additional components for investigating the needs, for training and capacity building are essential and they should be designed with local community involvement.

Awarding of Funds. An efficient internal management, streamlined procedures and a transparent and participative process for identifying projects and awarding funds is essential. At present, projects funded by USF/UAF in several countries can take up to five years from design to bidding.

Multisector participation and cooperation among key stakeholders[17] is essential for common planning and sharing of resources and ideas in designing and implementing USF programs. This coordination should ensure that different initiatives are built in a complementary and cost effective way, avoiding duplication of efforts and resources.

Improvements of the Tender Process for Broadband Projects. The following actions are recommended:

- Evaluate tenders based on total economic value of each proposal. In particular, spectrum licenses and other concessions should be included in the total economic cost of any proposal.
- Require true broadband service: 1 Mbps downlink and 256 Kbps uplink.

[17] E.g., the national government, departments responsible for telecommunications and ICTs, education and health officials, the regulatory authority, universal funds administrators, energy and transportation infrastructure specialists.

- Mandate higher availability requirement for backbone connectivity: it should not be limited to a few hours a day as it is currently common in several rural areas across Latin America and the Caribbean.
- Mandate affordable broadband pricing.
- Focus on community broadband connectivity**:** solicit proposals that include business plans to provide broadband connectivity not just to a telecenter but to other parts of the community as well.

Training and capacity building. To promote social inclusion and economic development through local broadband access networks, government personnel at strategic levels, the business community, the formal education system, businesses and final users have to be aware of the benefits and know how to use these technologies. Training and capacity building should therefore be an integral component of the USF programs financing strategy.

Regulation

Radio Spectrum management and licensing. WLAN technologies represent a key enabling factor for local access networks. Lack of access to available radio spectrum is a barrier to the expansion of telecommunications networks implementing innovative wireless technologies. This may involve restrictions in the allocation of frequencies or expensive and complex procedures for obtaining the license that should be removed.

Interconnection. The provision of telecommunication services at local level requires access to facilities often controlled by incumbent operators. Interconnection to national carriers has to be achieved at a rate that is profitable for both carriers and maintains service affordability for end users. It is therefore recommended that Regulators issue and enforce norms on maximum permissible delays in the signing of interconnection agreements.

Tariffs and interconnection charges. Asymmetric interconnection charges enable rural operators to pay less to terminate their outgoing calls on the networks of larger fixed and cellular operators and to charge more to terminate incoming calls from those operators on their own networks. Allowing rural operators asymmetric termination arrangements and prices – as it is currently happening in Peru - can reduce subsidy needs and improve the rural operator's financial viability.

Backhaul pricing. High prices for leased capacity can undermine the financial viability of networks serving smaller markets. In those cases where competition dynamics cannot ensure competitive prices, Regulators should introduce measures to ensure that backhaul capacity pricing is not prohibitive.

Technological neutrality. Technological neutrality is an imperative in the current environment of rapid technological change. Wireless technologies such as Hyperlan, Wi-Fi, Wi-Fi Mesh and WiMAX have enjoyed wide adoption in the implementation of economically feasible solutions. With VOIP, voice and data can be delivered over a single wireless broadband network. In Brazil, GSM 900 has proven effective in providing affordable fixed telephony. Third generation mobile technology operating in the 450 MHz band has been deployed in Peru as the most effective solution to deliver not only voice, but also broadband, in rural areas.

Infrastructure sharing. In pursuing rural network deployment, infrastructure sharing (e.g. towers, power lines) can reduce start up costs for rural operators. Under reasonable commercial arrangements, the price for use of shared infrastructure is a fraction of the cost of building proprietary infrastructure.

Investors and financing

Telecom projects, even with the use of much more cost effective technologies such as Wi-Fi or WiMAX, are still capital intensive. They require the mounting of towers, the availability of backhaul infrastructure and the provision of customer premise equipment.

Private participation. The need for a strong involvement of the private sector remains undeniable. In order to be more effective and sustainable, universal access funds must evolve from the role of providers of state subsidies towards encouraging markets and offering incentives for private provision of services on a commercial basis.

Financial instruments need to be structured appropriately with longer terms for repayment at market interest rates, keeping in mind that these projects target communities with a lower purchasing power, lower potential to generate profit, and a lower ROI.

Key elements of a LBAN

Vision. Focus of the project should be on connectivity as a tool for meeting real needs of the population to be served. The approach cannot be designing solutions without investigating the real demand from end users.

Network project. Well designed network projects present the following attributes:

- Clearly defined network objectives
- Accurate technical economical-analysis leading to a technological choice, service definition and network dimensioning: financial, and technical (coverage, service requirements) benchmarks are highly correlated in these networks. The technical-economic analysis has to take into account:
    - The peculiarities of the region to be served: topography, propagation environment (sub-urban, rural, open-rural), population density
    - The coverage requirements (outdoor, indoor)
    - The features of the community to be served (population density, demographics, economic activity, income, ability of users to pay for service) and local politics
    - The services to be delivered by the network
    - The requirements of the backbone network both in terms of capacity, technology (dependent on the distance of the region to be covered from existing network facilities), and costs.
    - The available spectrum options (frequency bands, licensed, unlicensed spectrum)

Due to the complexity and the number of factors entering into a broadband network project, an essential element in all phases of the project is information sharing among players on particular regional requirements and circumstances, available technical and financial solutions, proposed regulatory adjustments and service and market opportunities.

Business model and partnership arrangements. The following actions with respect to partnership and commercial arrangements are recommended:

- Project manager, technical personnel, and others involved in a network project have to explain the concepts and the benefits of implementing a local broadband access networks to participating local institutions, organizations and community leaders from the start.
- Involved stakeholders have to define a clear and formal organizational structure, including a written agreement containing the arrangements for service level, network administration and customer billing. Public sector may need to take an equity role in the network, especially in areas where access gap is due to sustainability issues.

- Clearly defined conditions between the local access network operator and the backbone capacity provider for pricing, and service levels, including compensation if they are not met. The local community organizations involved, including local governments, schools, hospitals, agricultural and other associations have to commit to sharing costs either through a specific budget item or a user fee. A strong commitment from the Municipality, assumption of responsibility, and an agreed upon roadmap for involved parties are recommended as essential elements for the success of this kind of initiatives.

Stakeholder involvement in the implementation of local networks is essential. Involvement of NGOs and Institutions committed to local community's economic and social development, although in different sectors (e.g. agriculture, commerce), is a key success factor. Economic development for rural areas requires not only the deployment of ICT, but an eco-system of various actors (NGOs, private associations, Universities, Institutions, and Local Governments).

Deployment of technology, when integrated with a global effort for development, has strong impact on social development and economic inclusion. In this framework, the availability of Internet connectivity becomes a mandatory component for local SMEs to develop their business and to integrate in a sustainable value chain. Collaboration among different actors expands the opportunities for providing good quality training, building capabilities, fostering small business opportunities and creating jobs.

Business Planning. In order to ensure long term sustainability of the project, a careful evaluation of revenues and costs, particularly in areas where service affordability for households may be a major issue, is a key stage in business planning. Some factors can dramatically drive costs up:

- Costs for sales and management
- Distribution and logistics are critical factors, a good distribution system is fundamental
- Power supply shortages and the need for extra equipment
- The cost of the Customer Premises Equipment (CPE) and the need of operator subsidization

Tariffs. Experience in collecting payments from users is crucial for the operator. In many cases prepaid service has been recommended.

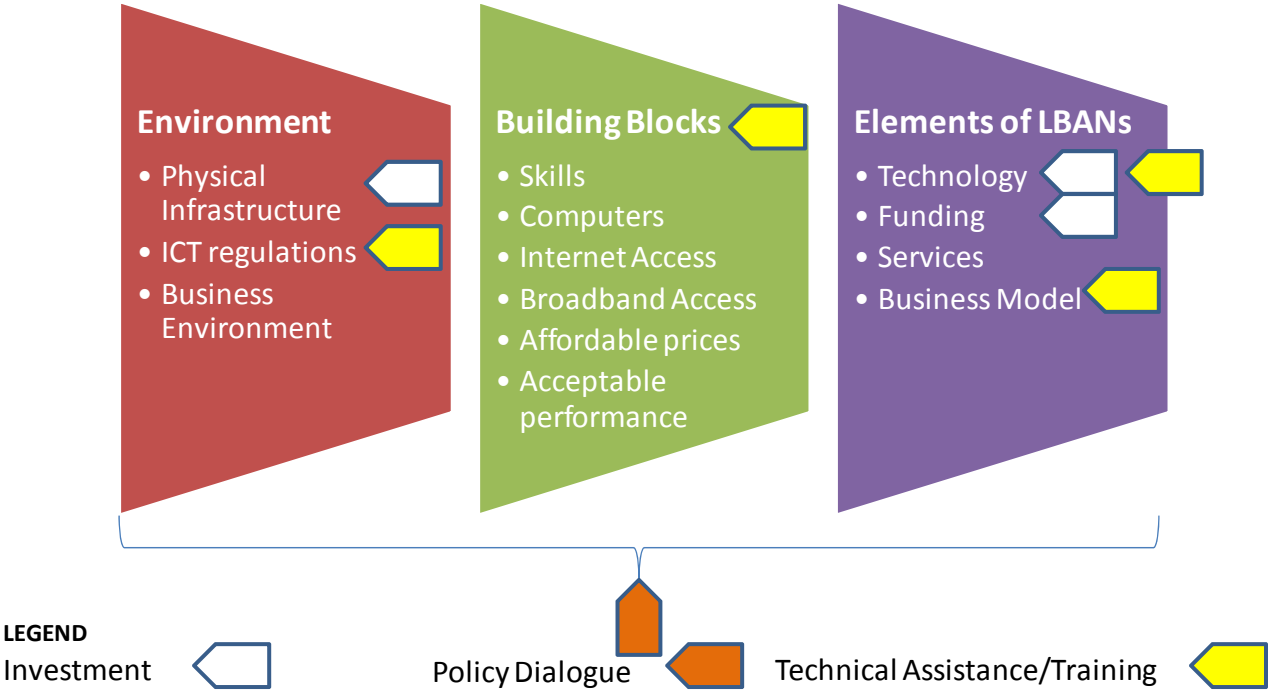
Managerial Skills. Involvement of local communities in network management and commercial operations is recommended as an enabling factor for local development.

Content and services. The success of the broadband deployment project depends strongly upon localized content and applications. Governments have a key role to play in promoting valuable content particularly if they accept to provide e-government services through the network.

Possible role for donor intervention

Donors can support local broadband access networks by intervening through policy dialogue, technical assistance, training and investment operations at three levels:

1. The enabling environment
2. All six building blocks (ie., skills, computers, internet access, broadband access, affordable prices, acceptable performance)
3. Individual elements of a local broadband access network (technology, funding, services and business models)



Policy Dialogue

Policy dialogue is pervasive and essential. Many LAC countries do not need external financial support but advice from an honest broker that could promote rural telecom as an opportunity and bring operators, regulators, universal service fund managers, policy-makers, and organizations from the target rural communities together.

Coordination among donors and institutions for universal access projects and e-government strategies is also essential for the development of the sector.

Technical Assistance and Training

Donors could also provide technical assistance and training to different players on specific topics.

For regulators, regulators, established operators and rural entrepreneurs, they could cover:

- Specific regulatory elements that provide an enabling environment,

- Second generation USF policies or programs that provide incentives to carriers and rural entrepreneurs to deploy broadband in underserved areas,
- Showcase experiences and business models proving how rural telecom can be a profitable venture for the private sector and,
- The role of rural entrepreneurs in developing rural telecom services and growing ICTs businesses thanks to the availability of broadband Internet access.

The various stakeholders of Local Broadband Access Networks need instead technical assistance and training in these areas in particular:

- Business model definition
- Technology and market assessment and ISP management
- Preparation of engineering design and business plan
- Training for local staff on project and financial management
- Basic IT and Internet training for digital inclusion.
- Knowledge management and replication.

Investment

Investment finance is needed at three different stages of the development of local broadband access networks:

- **Early Stage**. To date, projects like USAID's Last Mile Initiative – which has been closed - have provided seed or angel investment towards building out projects at a "proof of concept" stage. MIF could continue to fund technical assistance for innovative pilots in coordination with other donors for the investment costs.
- **Start-up**. Projects that have been successful in the early stage, require start-up funding in order to begin to scale up and replicate the success achieved during the initial stage. The IDB could play a role here, directly or through the IIC.
- **Scale up**. To take these types of projects to regional or national scale, larger capital injections through loan programs or other financial instruments. Investment funding could be provided in cooperation with each country's UAF and capital markets to ensure sustainability.

Equity, loans and guarantees could be used in different combinations and be provided by different donors or multilateral organizations. Output Based Aid (OBA) could also be considered for any form of grant funding, as it has been recently piloted in Indonesia under a Rural telecom project funded by the World Bank.

ANNEX 1 – BROADBAND STATISTICS

The ITU ICT Development Index (IDI) by country (2002 and 2007, minimum 1, maximum 10)

Index	Average value 2002	Average value 2007	Change	Level
All Countries Average	**2.48**	**3.40**	**0.92**	
Argentina	3.06	4.12	1.06	Upper
Chile	2.97	4.00	1.03	Upper
Uruguay	2.90	3.88	0.98	Upper
Jamaica	2.79	3.78	0.99	Upper
Trinidad & Tobago	2.50	3.61	1.11	Upper
Brazil	**2.55**	**3.48**	**0.93**	Upper
Panama	2.42	3.46	1.04	Upper
Costa Rica	2.54	3.41	0.87	Upper
Venezuela	2.18	3.34	1.16	Medium
Colombia	2.13	3.25	1.12	Medium
Peru	**2.15**	**3.11**	**0.96**	Medium
Mexico	2.38	3.09	0.71	Medium
Ecuador	1.97	2.75	0.78	Medium
Dominican Republic	**1.97**	**2.65**	**0.68**	Medium
Cuba	1.94	2.53	0.59	Medium
Paraguay	2.02	2.52	0.50	Medium
Bolivia	2.03	2.45	0.42	Medium
El Salvador	1.74	2.43	0.69	Medium
Honduras	1.31	2.28	0.97	Medium
Guatemala	**1.60**	**2.28**	**0.68**	Medium
Nicaragua	1.37	2.03	0.66	Low
Haiti	1.05	1.27	0.22	Low

Source: ITU – Measuring the Information Society (2009)

Internet and Broadband Penetration by Country (2002 and 2007)

	Fixed broadband subscribers per 100 inhab.		Mobile broadband subscribers per 100 inhab.		Internet Users per 100 inhab.	
Country	**2002**	**2007**	**2002**	**2007**	**2002**	**2007**
Argentina	0.4	6.6			10.9	25.9
Bolivia		0.4			3.1	10.5
Brazil	**0.4**	**3.5**		**1.2**	**9.2**	**35.2**
Chile	1.2	7.9		0.4	19.1	31.0
Costa Rica		3.0			19.9	33.6
Dominican Republic		**1.6**			**7.3**	**17.2**
Ecuador	0.1	2.4		0.7	4.3	13.2
El Salvador		1.3			4.6	11.1
Guatemala		**0.6**		**0.3**	**3.4**	**13.1**
Jamaica	0.3	3.4		0.2	23.0	55.3
Mexico	0.2	4.3		0.3	13.3	22.4
Nicaragua		0.6			1.7	3.1
Panama	0.4	4.3			8.5	22.3
Paraguay		0.8			1.7	8.7
Peru	**0.1**	**2.0**			**9.0**	**27.4**
Trinidad & Tobago		2.7		8.0	10.7	16.0
Uruguay		4.9			11.2	29.0
Venezuela	0.3	3.1			4.9	20.7
LAC	**0.4**	**3.0**		**1.6**	**9.2**	**22.0**
ALL COUNTRIES		5.5		3.0		20.2
DEVELOPED COUNTRIES		19.4		14.0		55.4
DEVELOPING COUNTRIES		2.4		0.9		12.8
IDEAL VALUE		60.0		100.0		100.0

Source: ITU – Measuring the Information Society (2009)

ICT Access by Country (2002 and 2007)

Country	Fixed telephone lines per 100 inhab.		Mobile cellular subscriptions per 100 inhab.		International Internet Bandwidth per Internet user (bit/s)		Proportion of households with computer		Proportion of households with Internet	
	2002	2007	2002	2007	2002	2007	2002	2007	2002	2007
Argentina	20.5	24.0	17.5	102.2	1,336	8,943	27.0	36.4	14.0	27.5
Bolivia	6.8	7.1	11.8	34.2	169	398	7.1	18.0	1.8	5.9
Brazil	**21.7**	**20.5**	**19.5**	**63.1**	**570**	**2,955**	**14.2**	**20.8**	**10.3**	**15.4**
Chile	22.0	20.7	39.6	83.7	659	13,135	20.5	36.4	11.0	22.1
Colombia	17.8	17.2	10.6	73.5	349	3,528	10.0	27.4	5.6	
Costa Rica	25.3	32.2	12.3	33.8	623	2,440	20.0	31.6	7.3	11.8
Cuba	6.0	9.3	0.2	1.8	481	162	0.5	2.3	-	1.8
Dominican Republic	**10.7**	**9.3**	**20.0**	**56.5**	**83**	**894**	**5.5**	**12.5**	**2.8**	**5.7**
Ecuador	11.1	13.5	12.3	75.6	377	2,458	17.5	18.0	2.0	6.8
El Salvador	10.2	15.8	13.6	89.5	199	157	5.2	8.6	2.3	3.6
Guatemala	**7.2**	**11.0**	**13.5**	**76.0**	**1,625**	**1,429**	**5.9**	**13.6**	**0.6**	**1.8**
Haiti	1.6	1.1	1.7	26.1	746	155	0.3	4.0	-	1.8
Jamaica	16.6	13.5	47.6	98.6	3,333	34,000	13.0	17.3	7.7	12.7
Mexico	14.6	18.5	25.2	62.5	426	784	15.2	22.1	7.5	12.0
Nicaragua	3.3	5.0	4.6	37.9	67	4,697	2.2	7.8	0.6	3.6
Panama	12.6	14.8	17.2	90.1	2,382	71,616	9.8	16.9	5.8	8.9
Paraguay	4.8	6.4	29.0	76.6	1,000	1,886	5.4	10.4	1.7	4.0
Peru	**6.2**	**9.6**	**8.6**	**55.3**	**565**	**9,877**	**4.3**	**13.8**	**0.8**	**5.6**
Trinidad & Tobago	24.6	23.1	20.3	113.2	696	4,229	17.0	43.6	15.5	18.1
Uruguay	27.9	28.9	15.1	90.0	987	3,102	17.6	27.0	13.6	13.5
Venezuela	11.2	18.4	25.8	86.1	555	3,016	5.1	11.9	2.0	3.0
LAC	**13.5**	**15.2**	**17.4**	**67.9**	**820.4**	**8,088.6**	**10.6**	**19.1**	**5.4**	**8.8**
ALL COUNTRIES		18.9		49.8	1	8				
DEVELOPED COUNTRIES				100.3				75-85		75-85
DEVELOPING COUNTRIES		14.0		39.2						
IDEAL VALUE		60.0		150.0		100,000		100		100

Source: ITU – Measuring the Information Society (2009)

Price of Broadband Access by Country (annual cost as a percent of per capita GNI)

Couuntry	Price of Broadband (as a % of GNI per capita)
ALL COUNTRIES	**219**
ALL DEVELOPED COUNTRIES	**2**
ALL DEVELOPING COUNTRIES	**300**
Trinidad & Tobago	1.1
Costa Rica	3.7
Panama	3.3
Uruguay	4.6
Venezuela	5.1
Mexico	5.3
Argentina	7.6
Barbados	7.3
Grenada	6.3
Chile	7.6
Jamaica	9.7
El Salvador	7.6
St. Lucia	12
Dominican Republic	**9.5**
Ecuador	15.6
Dominica	13.5
Colombia	13.4
Peru	**12.7**
Brazil	**9.6**
Guatemala	**16.7**
Suriname	24.1
Paraguay	25.2
Belize	28.3
Guyana	45.7
Bolivia	31.9
Nicaragua	36.7

Source: ITU – Measuring the Information Society (2009)

ANNEX 2 – BUSINESS CASE STUDIES

1. The SIA Project in the Huaral Valley of Peru.

The project

The Sistema de Informaciòn Agraria (Agrarian Information system, SIA) project was promoted by the NGO CEPES in the Huaral Valley of Peru. The Huaral Valley is on Peru's Pacific Coast, 90 kilometers north of Lima. It has a subtropical arid climate and its agricultural production relies on irrigation. The valley encompasses three districts – Chancay, Huaral and Aucallama – that form part of the province of Huaral (which itself forms part of the region of Lima). Together with the district capitals – of which the city of Huaral is the largest – there are several small settlements that lack basic services such as roads and telecommunications.

Many public institutions, including all of those related to the agriculture sector, did not have access to the internet. The agrarian information system had following objectives: help small farmers to have a better negotiation power by being informed about the pricing structure in the region, contribute to ICT appropriation by farmers and the rest of the population; improve the administration of the Irrigation Board and provide farmers with access to useful information. Additionally, it has become a tool to communicate and manage better the water supply.

Network Technology

The project involved the installation of telecenters in rural communities and the creation of a web-based information system for water management and cultivation monitoring.

A Wi-Fi network was deployed joining twelve villages in the valley and connecting them to the Internet through a shared 512 kbps link. The technological choice allowed network deployment with a modest initial investment (about UUS$ 16,000 per village).

Services

The SIA project supports the following services:

- Interconnection between the 12 Huaral Valley irrigation commission information centers.
- An information system (YACU) for water resource management and cultivation monitoring.
- Access to the internet through 62 PCs at the telecenters This service is provided free of charge for farmers and their families to access agrarian information, and for USD 0.30 per hour for other uses

Telecenter administrators provide free agrarian information through web searches and a bulletin board, which is useful to give information to those who still do not feel comfortable using computers. Telecenters offer photocopy and scanner services, which were previously unavailable in most of these places.

VoIP not only for linking the local Irrigation Commissions and the Board but also for general use by local residents.

The project provides wireless internet access to public institutions and small enterprises, residential demand is limited.

In an initiative recently promoted by CEPES, Nokia Smart Phones have been distributed in the area of the Huaral Project, to allow users to enter data about the water management as opposed to having to go to the

telecenters. They have established a Wi-Fi WAN to provide coverage for the Wi-Fi enabled SmartPhones using local manufactured Wi-Fi equipment. Netkrom is the equipment manufacturer.

Financing

While the project was initiated by CEPES, the structure and financing of the initiative involved a partnership arrangement between different actors. The initial cost (about UUS$200,000) was jointly financed by the Ministry of Agriculture, FITEL and the Water Users Board, which was also selected as the owner/operator of the network because of its experience in managing infrastructure and its close contact with local farmers.
It is now supported by the small farmers' organization, JUNTA DE USUARIOS.

Conclusions

Although, there are 52 valleys on the coast of Peru that have similar characteristics as the Huaral Valley and have an interest in VoIP as well as Internet access to use the water management software applications, there are no plans for scaling up the project or enhancing network capacity. CEPES is currently focused on the implementation of the YACU information system for water resource management and cultivation monitoring.
CEPES has received funding from a Dutch organization and a German organization to focus on issues related to rural development and is involved in projects in partnership with IDRC. With IDRC and Swiss Development Corp., CEPES is working on a project (www.telecentre.org) which is a sort of social network for Telecenter operators where local operators and NGOS throughout the world can share info and expertise about how best to leverage a telecenter to promote economic development. They have to learn how to use NING (www.ning.com), which is the software that was used to set up their social network.

2. Rural telecommunications Micro Entrepreneurs in Cajamarca – Peru

The project

Cajamarca is located in the northern highlands of Peru. Cajamarca is bordered to the north by Ecuador, to the south by La Libertad, to the east by Amazonas and to the west by Piura and Lambayeque. The city of Cajamarca is 2,750 m above sea level, and located about 856 Km north of Lima, capital of Peru.

The Intermediate Technology Development Group (ITDG), an international development agency, executed, from 1998 to 2001, InfoDes project which aimed to run an information system for rural-urban development focusing on small rural farms and local governments.

Since then, a set of projects began in order to extend the InfoDes Project. One of these, the "Connecting The Andes Project" was born with the purpose of creating a Rural Telecommunication System responding to the needs of local population.

Six pilot infocenters were installed in La Encañada, Chanta Alta, Combayo, Huanico, Puruay Alto y Llacanora areas.

The Connecting the Andes project designed a network management model aiming at answering to community needs. Most of local people who started working at the project ended up being entrepreneurs who managed the Infocenters.

The project promoted public private partnership as the most suited model for expansion of rural communications.

In order to meet characteristics of rural telecommunications services and manage the public network according to the community needs, an organizational and business model involving following actors was proposed:

- **Legal Owner** representing the government or community. Although the radio belongs to 'the entire community', only one company can legally own it;
- **Local Administrator/Operator** the legal owner selects the local operator through a public tender the local. Local operator is awarded a concession.
- **Supervising Committee which** comprises members from local organizations and institutions the entity that allows the community to oversee the work of the legal owner and the administrator.

FITEL decided that the infrastructure including the local computers would belong to the local operator, Gilat to Home (GTH). Standard contracts that GTH had with its concessionaries did not foresee citizen participation and did not target local development.

This hybrid model went wrong because of the complex business model which left out the community component.

Network technology

Recently, the Municipality of Cajamarca with the Project "Multi-access System Service", promoted the deployment of a metropolitan wireless communication network in order to promote the expansion of ICT service and create more efficient ways to enhance citizen services. Wireless Base Stations using Dual Band Pre-WiMAX technology were deployed all over the city of Cajamarca giving Internet Access to residential and business and interconnecting all council offices offering multiple services in a decentralized way. Three different subnets, segment the Broadcast Domain generated by IP Data Traffic of:

- LANs in council offices.
- WLANs working at 5.8GHz (operating as the Backbone of the Wireless Platform).
- WLAN of mobile users (laptops, Pocket PC, etc.) that are able to access the internet through the Wireless Internet Service (HOT SPOT) at 2.4GHz offered by the Municipality of Cajamarca.

Services

- **Data, Voice and Video using TCP/IP protocol**.- Every City Hall Headquarter is provided with Voice over IP service, and Video over IP is used to support video conferencing for personnel .
- **On-line Multiple Services**.- Internet access for residential and business, on-line governmental services

Financing

FITEL financed the initial phase of the project with the intention of testing benefits and sustainability of local access networks and related services.

Regulation

No regulatory constraints were found in the review of this business case.

Conclusions

City Hall Headquarters in Cajamarca are today wirelessly interconnected. All employees from each City Hall Headquarter take advantage of the connectivity between their PCs, having a better management of the information and network resources. Before the Wireless Solution was implemented some headquarters were interconnected using VPN's through the local ISP with data rates from 256 Kbps to 512 Kbps. When the Wireless Solution was finished the real throughput achieved was about 10 to 15 Mbps on different locations.

The Wireless Base Stations are upgradable to WiMAX or can be used on the Public-Safety Band of 4.9GHz.

More details are available at Cajamarca website http://www.municaj.gob.pe/

3. LOCAL in the State of Ceara - Brazil

The project

Ruralfone Inc., a US based Company, was established in 2002 with the aim of providing the most affordable basic phone service with an exclusive focus on small to medium sized villages and cities in developing areas. Ruralfone's adopted mode consists in establishing operations in each selected town through local subsidiaries with particular emphasis on improving the living conditions of the served communities.

Through its Brazilian subsidiary, LOCAL Servicos de Telecomunicacoes Ltda, Ruralfone launched its service in the city of Quixadà, a medium sized city located in the semi-arid interior of the state of Cearà in Brazil's northeastern region, in May 2005. Brazil was selected as a basis for Ruralfone operations essentially for two main reasons:

- At the level of independent companies or organizations, there is no regulation limiting the way in which internal telecommunications are structured, managed, and priced and the business model that can operate within the existing legal framework. Ruralfone applied for a national license but the service can be operated on a regional base (regional licenses are available).
- Possibility to use mobile frequencies for fixed applications. The technology underlying the service is not an issue for Ruralfone, the primary concern was to provide voice service to low-income people in areas with extremely low penetration of fixed lines. Voice was identified as a primary need, GSM technology was selected because the very cheap cost of the handset and declining equipment cost.
- Ruralfone is present in four municipal districts: Quixadà, Quixeramobim, Russas and Aracati, in the eastern part of the State – its main operation is in Quixadá. The choice of the Company is to serve the market at the bottom of the pyramid. Average income in the districts of operation is 1.000 US$ per capita per year.

LOCAL seeks to address the millions of low income subscribers who are not served by larger operators.

LOCAL obtained an STFC (Servicio de Telefonia Fixa Comutada) license to offer fixed telephony service in all of the State of Ceara. LOCAL obtained also a 2 x 5 MHz frequency allocation in the 1800 MHz band to deploy a fixed wireless system. LOCAL deployed a GSM-based wireless network in the town of Quixadà.

Network technology

The LOCAL network is based on standard off the shelf GSM technology. Equipment is manufactured in Brazil and is not, therefore, subject to taxes on foreign manufactured equipment. The network set-up phase was made easier by cooperation with regulator in Brazil, which opened up the possibility for operator to acquire geographically limited fixed licenses at a low price and take advantage of unused mobile frequencies

LOCAL has an interconnection agreement with Telemar and all other mobile and long distance operator which operates in its region. Physically, LOCAL is interconnected only to Telemar which provides traffic transit to all remaining operators to which LOCAL is interconnected. LOCAL has also a site-sharing agreement to use Telemar' rights of way and towers.

The Company is technology-agnostic, as focus is on providing affordable service, whichever the underlying technology (technology neutrality). Service penetration (by Local) had a 70% growth in 3 years. In his interview,

Denise Cote provided following statistics: in Brazil the average consumption over mobile is 70 minutes/month/subscriber. For local it is 600 minutes/month/subscriber thanks to the simple and cheap tariffs and low termination costs.

Services

LOCAL operates currently in the cities of Quixadà, Quixeramobin, Russas and Aracati.

The Company encompasses today five thousand subscribers, three thousand of these only in the city of Quixadà, where it divides evenly the market with Telemar.

LOCAL does not subsidize GSM handsets, supplies only the SIM cards and offers two very cheap basic plans: the "Without Control" that charges R$39 for unlimited calls within the whole city coverage area and the "Popular Local" that has a price and operation system similar to the pre-paid cellular phone plans with validity of six months for the credits and recharges of R$ 5, R$ 10 and R$ 15.

LOCAL has plans for extending its service to smaller cities in Cearà, Pernambuco and other States of the Northeast. Even smaller cities with 10 thousand inhabitants, some of which have only 80 fixed Telemar lines to serve the whole municipal district.

Service uptake has been impressive and LOCAL's presence in Quixadá and other remote cities has had a huge impact on residents. The local economy is already seeing the results and small companies are now able to find more business opportunities.

The delivery of Internet services had a significant development impact on areas where service is active:

- **Increased connectivity**: Ruralfone has reached 12% penetration in the towns where it is active. 75% of subscribers did not have a fixed line prior to acquiring service from Ruralfone. Further growth is still expected as national penetration average is over 20%. A repetition of these results in cities where network is expanding is expected.
- **Improvement of local economy and business environment**: Small business entrepreneurs and service providers have seen an increase in productivity from better connectivity to the local population as a result of faster business transactions and better information. About one third of Ruralfone lines are taken by local SME's as their business line.
- **Local employment and skills generation**: Ruralfone has a decentralized structure. It hires and train management from the local population, building important skills for the local people in the process. The vast majority of employees are from the villages where the service is offered. This provides new opportunities to local people. The team gets regular training, some have evolved towards managerial positions in neighboring cities and have succeeded in spreading a new culture to wider areas of the State. Local businesses are used for printing and promotions, creating a business model which strengthens the regional economy.
- **Improved social and governmental services**: in the towns where the company operates, the local government has been able to increase by more than ten times the number of operated telephone lines, improving accessibility to the community and response times. Additionally, the cost effective service has allowed local governments to provide additional social benefits such as hot lines and tourist information lines.

- **Increased local tax revenues**: Ruralfone has become one of the highest VAT contributors in the cities where it operates. Local Telecom attained, in its Quixadá unit, the profit goal of 50% before interests, taxes, depreciation and amortizations (EBITDA) - profitability superior to that of the operators of conventional fixed telephones. With the operation in this city, the company invoices the equivalent of US$ 30 thousand a month.

Financing

The project sponsor is the management who initially together with Denis Cote, President and CEO of Ruralfone Inc, Brazil, financed the project.

The initial investment was of US$ 1 million, obtained through Canadian, North American and European investment funds, and another US$ 1 million from an agency of the American government created to foment the development of small businesses by companies abroad.

In April 2008, the project obtained a financing of US$ 3 million through the IFC (International Finance Corporation) to expand its service in Brazil to another ten cities in two years. At present, there are 27 shareholders, most of them individuals. Management holds about 67% of the company. Local does not receive any government fund.

Regulation

Ease of getting a license and signing interconnection agreements was possible because of a favorable regulatory environment created by Anatel, the national Regulator.

Conclusions

Focused marketing is especially important for local commercial undertakings. Ruralfone, a small new entrant, offers a simple, economical, community-oriented service. The business model allows access offer at a much more affordable price than competitors.

The project and the adopted business model have been successful for the following reasons:

- Focus on local community. The stall is locally recruited, the company has tailored its offer on the needs and concerns of local population.
- Cost efficiency LOCAL decided to establish its operations in the villages and this, together with cost-efficient technology, has resulted in lower operational expenses.
- Minimal fees for obtaining licenses
- Choice of a mature standard technology
- Good relationships with local governments, sponsorship and participation to local events
- Ease of getting a license and signing interconnection agreements because of a favorable regulatory environment created by Anatel, the national Regulator.

There are plans for expanding the service to 60 additional cities. The plans for the future services can be summarized as follows:

- Covering in next 2-3 years 60 more villages
- Expanding voice service using whichever technology allows to contain the customer fee
- Broadband service with a technology-neutral approach

4. Castanhal City, Brazil

The project

Castanhal is a mid-sized Amazon city. The pilot project focuses on providing a local broadband access network to Castanhal in an environment which may be considered suburban/rural.

Network technology

It was proposed the use of a mix of low-cost WLAN technologies and hybrid systems including optical fiber:

- Wireless: Wi-Fi and WiMAX core and access WiMax uses the 4.9GHz licensed frequency band.
- Optic Fiber: Core
- Cable/LAN

Services

Internet, Intranet, VoIP, CCTV, Video conference, IPTV, others. **Network users** are: public schools, hospitals, government buildings, rural communities.

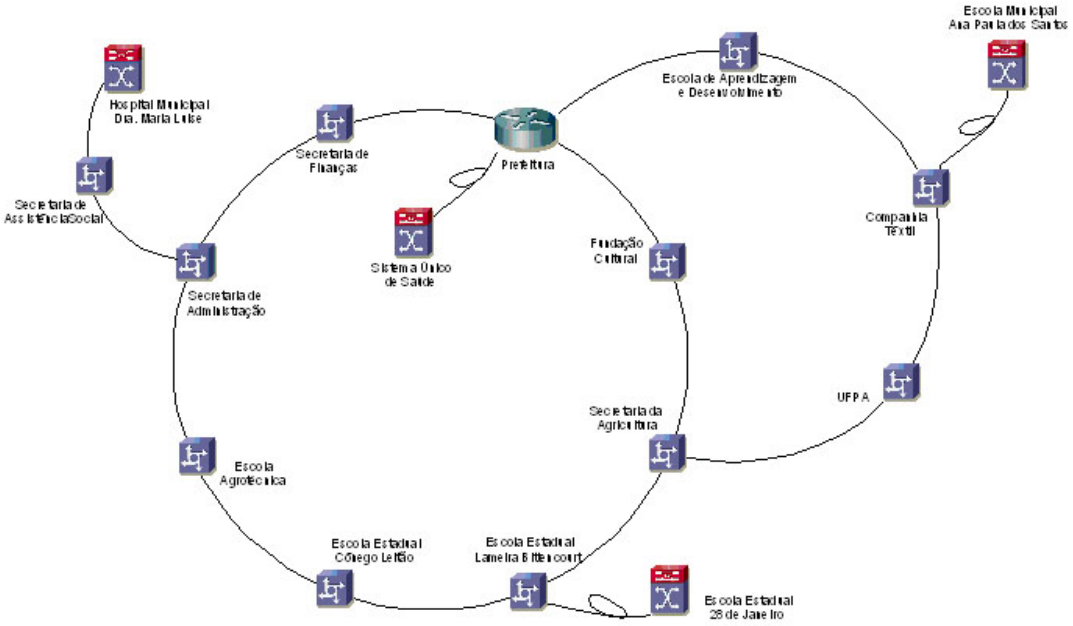


Figure - Castanhal City Network Topology

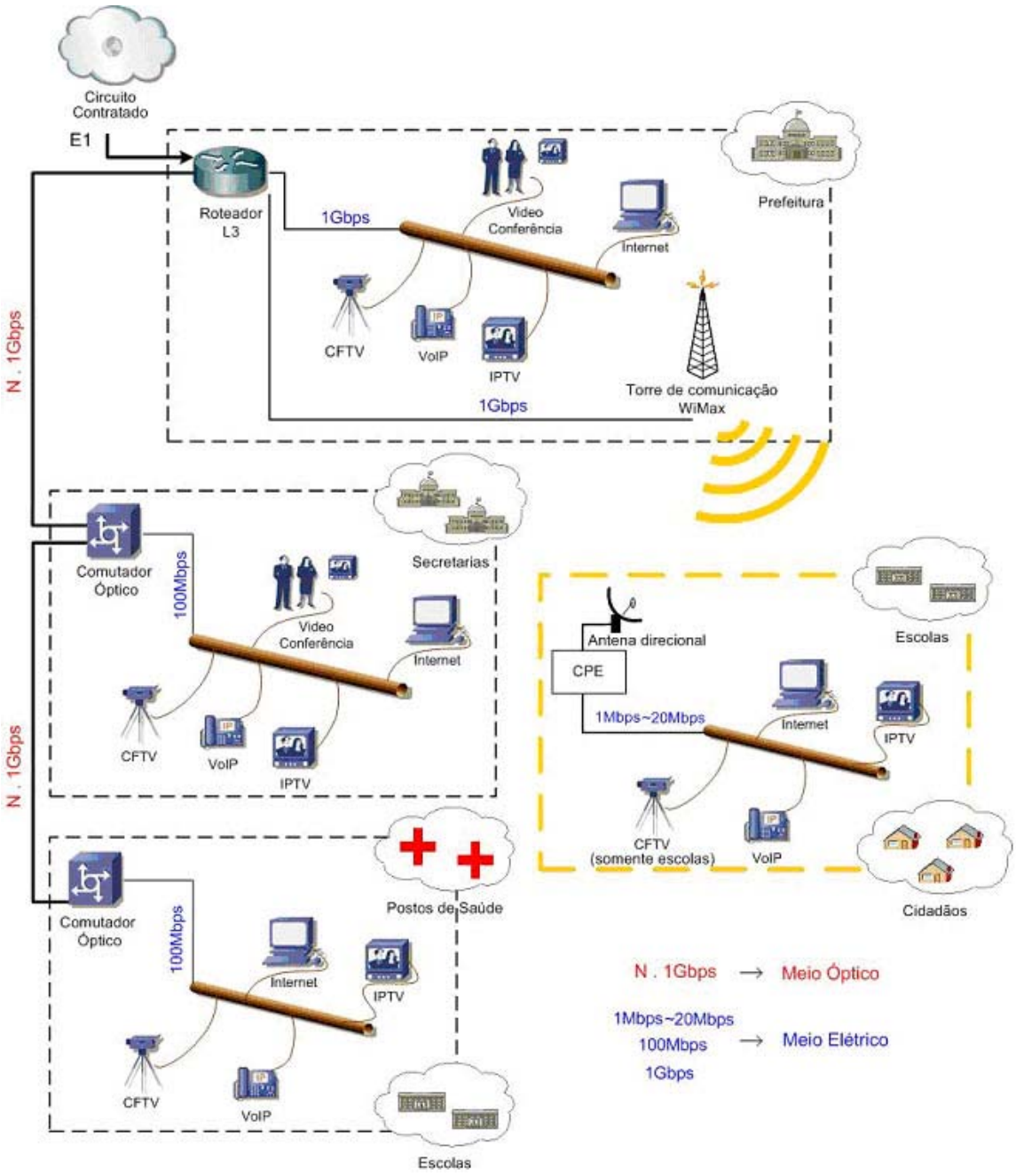


Figure - Castanhal City Network Overview

Business Model

The project was sponsored by a public-private partnership. The private sector pays most of the project costs, while the local public government provides broadband access and controls the network.

5. Pedreira City – Infovia Project (Brazil)

The project

The Pedreira City network is an example of deployment in a suburban environment. Pedreira has a population of 40.269 inhabitants, spread over an area of about 110 sq. km., with a population density of 369,8 inhabitant pr sq. km. Of the city's 12,000 houses, almost 1000 are inside the coverage.

This project is very similar to Castanhal City pilot project. The Infovia of Pedreira, developed from a partnership with the University of Campinas, is the first "communitarian broadband access network" developed in Brazil with capacity to provide digital convergence of the technologies that works with audio, data and image in a model of distribution of communitarian access.

Network technology

Access Network: Wi-Fi – 2,4GHz license-exempt,
Backhaul: Optic Fiber
Services

Internet free, VoIP, CCTV, Video conference.

Network users are public schools, hospitals, government buildings, local population in general. In the first phase of the Pedreira project only public access will be supported for institutional services.

Business Model

The project was sponsored by a public-private partnership. The private sector pays most of the project costs, while the local public government provides broadband access and controls the network. CPEs are partially financed by the manufacturer.

6. Ecuador Mesh Networking in the Amazon basin

The project

Yachana in the Amazonian region of Ecuador, is located 2.5 hours by motorized canoe from the nearest small city. The environment is a tropical rainforest with an elevation of 330 meters, the average temperature is 26°C, and there are no access roads. The Foundation for Integrated Education and Development (Funedesin), a nongovernmental organization (NGO) dedicated to community development, has deployed in Yachana a wireless mesh network connecting Yachana Technical High School, the Yachana Lodge Ecotourism Center, Yachana Reserve Biological Field Station and the Mondaña Medical Clinic. The network was supplied by LocustWorld.

Network technology

As in Yachana, there is no electricity, the system relies uniquely on solar power. Network topology is wireless mesh with VSAT connectivity for the backhaul. Due to the propagation conditions, LOS was required. Wi-Fi Mesh is the technology adopted for the local access network. The different sites are between 1.5 km and 5 km apart and the Wi-Fi mesh is connected to the internet via a VSAT link. All power for the mesh boxes and laptops is provided using a 3.5 kW solar panels array. VoIP is used to provide voice services within the network and to link users to the PSTN through Skype. It took one week to deploy the network, for a total cost of 28,000 US$. The satellite connectivity is extremely expensive: 700 US$ per month for capacity leasing plus the cost of a technician who once a month makes sure that everything is working.

Services

The Yachana integrated center consists of a technical high school, an ecotourism lodge, a medical clinic and a bioscience center. All of them benefit from being connected among each other with the Wi-Fi network and with the outside world via the VSAT link.

The Yachana High School, founded in 2005, offers a degree in Ecotourism and Sustainable Development, specializing in Ecotourism, Conservation, Agronomy, Animal Husbandry and Micro-Enterprise development and serves students from four provinces in the Amazon, all of whom are very poor. Access to the internet provided through this local network has brought educational benefits to both teachers and students.

The Medical Clinic that FUNEDESIN built in 1997 gets a great benefit from being online. Through Tele-Medicine supported by the Internet connection, the medical residents going their annual rural year of service, have live telemedicine consultation from this remote clinic to experts in the Metropolitan Hospital in the capital city of Quito, or throughout the world.

Yachana Lodge, with 2,000 annual visitors, is busy all year round. Having an online connection is a great service for visitors, who can maintain their contacts with the rest of the world while they are enjoying the jungle experience. Profits from the business go towards funding the Yachana Technical High School. VoIP is used to provide voice services within the network and to link mesh users to the PSTN through Skype.

Financing

FUNEDESIN has financed the deployment of the wireless mesh network. The network is not commercial and provides services exclusively to the local school and to the local health clinic. It does not provide commercial services. Customer Equipment is not subsidized.

The Foundation relies heavily on donations. The 700 US$ for the satellite connectivity and monthly maintenance are derived almost entirely from donations.

Regulation

Wi-Fi Mesh networks operate on frequencies with no license requirements. No regulatory barriers to network deployment and service delivery were met.

Conclusions

The network supports education, science, medicine and eco-tourism. The network is an interesting example of practice which sees the involvement of an NGO, Funedesin, in local network deployment. Funedesin aims to be self-sustaining through eco-tourism and micro enterprise, and got recognition for the world-class pioneering work in these areas from many major institutions (Yachana Lodge was awarded the "Conde Nast Ecotourism Award" 2004 and was a finalist in the World Travel and Tourism Council award 2005).

7. Rural Telecom Project and the Rural Broadband Project in Peru

The project

Rural Telecom (www.contactorural.com.pe) is a 100% Peruvian rural telecommunications provider operating since 2001 in the entire Country. Rural Telecom is owned by three Peruvian partners and entirely formed with Peruvian capital. The three partners also form the board of directors. The Company was officially founded in 2001 when it was assigned funds by FITEL to operate 1000 public phones with VSAT and solar kits in the central north of the Peruvian cost and highlands. In the last years, Rural Telecom also acquired additional public and private clients in all rural areas of the Country. The Company has its own logistical, operational, commercial and engineering units as well as decentralized offices in several provinces. Permanent staff is composed of 90 employees.

Rural Telecom was assigned the BAR project (see section 2.2 for details) for the following areas:

- Central Peru (Departments of Huánuco, Lima, Junín, Pasco y Ucayali), impacts on 450,000 inhabitants in 714 communities. Following services will be deployed: 416 telecenters, 416 public telephones, 89 residential telephony lines.
- Central North (Departments of Amazonas, Ancash, La Libertad, Loreto y San Martín), impacts on 316,608 inhabitants in 542 communities. Following services will be deployed: 454 telecenters, 291 public telephones, 40 residential telephony lines.
- North East (Department of Cajamarca) impacts on 348,659 inhabitants in 653 communities. Following services will be deployed: 613 telecenters, 389 public telephones, 19 residential telephony lines.

Network Technology

Different environments (urban, suburban, rural) will be covered by the network. Several technologies will be deployed to support voice and data services:

1. Core VoIP Platform – Data Center
2. Backhaul (Point-to-Multipoint)
3. Access Network (CDMA in the 450 MHz frequency band, Point-to-Multipoint, VSAT

The project combines the installation of new wireless technologies (95% of the project has to be innovative wireless, remaining 5% may be through VSAT) with a campaign for training and creation of content to be delivered over the Internet.

Services

The network will provide public and residential telephony and public internet access.

Network and Service deployment strategy

Rural Telecom is engaged in following activities:

- Campaign reaching more than 173.000 people (15% of the population of 1654 villages with more than 700 inhabitants)
- Training of about 3.500 entrepreneurs in basic management, leadership, marketing an d ICT management

- Training of 20.000 end-users in basic ICT use
- Generation of 1654 pages web pages in the communities' portals

In each village Rural Telecom staff identifies people willing to become entrepreneurs by investing their own money in telecenters that they will run and manage.

Where possible, Rural Telecom works with different stakeholders (agricultural associations, NGOs, local governments, International Cooperation) in order to increase the sustainability of the project.

The project is being implemented according to the following strategy:

1. Preliminary design and subsequent in field optimization of the wireless network.
2. Training campaign. Promoters from Rural Telecom visit the local authorities to inform them about the project and to search for their support. They visit the communities where infrastructure will be deployed, verifying the technical, economical and social viability in each village. In case of positive evaluation, they search for potential entrepreneurs. Once identified at least two potential entrepreneurs, the promoters hold one week face to face training course with them. In order to work more efficiently, groups of 10-20 entrepreneurs from different villages are formed. The course is organized around following modules: marketing, basic administration, leadership, use of the Internet, use of PC. The course has the central objective to support the entrepreneurs in developing their business and involve their community in the process. At the end of the training, best entrepreneurs sign a contract with Rural Telecom. Entrepreneurs pay for the cost of the PCs and have to provide a facility for the telecenter. Quite often it is their home. It is not allowed in most cases to use schools or municipal facilities.
3. Installation of the network equipment. In most cases a combination of ADSL and WiFi is used to connect the communities to the Internet
4. Training of end users. Rural Telecom provides a two day course to 12 end users in each village in basic ICT use. The group is made up of local leaders and students
5. Follow up activities supporting the economic sustainability of the project. These activities often see the involvement of NGOs, Universities and international cooperation. CEPES, ITDG, Engineers without Frontiers are involved NGOs, Cayetano Heredia University is also supporting.

Training is provided by Rural Telecom Staff and external consultants. 40 trainers that are independent contractors are full-time focused on the training program.

The Roadmap

Since 2007, Rural Telecom has completed 30% of installations and 50% of training. Plans are for completing remaining 70% by December 2009. In some places there are delays in interconnections mainly depending on Telefonica and due to following reasons: lack of infrastructure and difficulties in negotiations.

In almost 500 communities electricity is either completely missing or is not available 24 hours/day and this has two main implications:

- Difficulties in establishing Service Level Agreements with the local entrepreneurs.

- Telecenters have the obligation to provide public service 12 hours/day according to FITEL. This is impossible in those cases where electricity is not available and potential entrepreneurs are reluctant to engaging in a contract. In addition, in rural communities, most of the day people work in the fields and return to their communities only after 5 pm. Nobody attends telecenters during most of the business hours. (Rural Telecom is not yet providing the mobile telephony service. The plans for the project include a CDMA component to be developed in one year).

Financing

CAPEX is US$ 12 million. There's a US$ 8.8 million financing from FITEL. Financing will be disbursed over five year.

Regulation

Rural Telecom has all licenses as a national private rural operator for Internet and phone services (fixed line and public pay phones), with the exception of Greater Lima

Rural telecom are now eligible to get the CDMA 450 license for the three regions where they won the project.

Conclusions

A combination of social, economical, technical and rural development related factors have proved critical for the successful deployment of rural Internet.

- The time frame from the design of the project to the bidding, for very large ICT projects such as the BAR, may take up to five years. The mechanisms should be streamlined.
- The availability of technical infrastructure such as ADSL nodes and the achievable quality of the service have to be evaluated formally by all the stakeholders before the launch of the bidding
- Central training is recommended for technical personnel. Promoters should be selected among the local communities because they are more familiar with the local habits and needs, with the local politic dynamics and with the economic needs of the potential entrepreneurs who will run and manage the telecenters
- Rural communities and local entrepreneurs are reluctant to keep updated their websites. Economic and social incentives have to be implemented.
- Initial training programs need a permanent follow up as well as financing.

8. Peru: Televias Huarochiri

The project

Peru is divided into regions, provinces and districts. The province of Huarochiri is located in the region of Lima, the national capital. Haurochiri is divided into 32 districts covering an extremely rugged area of 5600 square kilometers with a population of 64,000 inhabitants. Population centers can be found from sea level to over 5,000 meters above sea level. Huarochiri can be regarded as a remote environment. Ruddy Valdivia, a small telecom Peruvian entrepreneur decided to bring telephone service to Callahuanca. The project was inaugurated on June 19, 2006.

Network Technology

The wireless network is built using the CDMA 450 technology which provides access both fixed and mobile in the 450 MHz frequency band for rural, suburban and sparsely populated areas. The reasons for the choice were as follows:

- The relatively large cell size decreases costs because fewer stations are required to cover a given area. In building coverage is also good in this frequency. Experienced cell radius is: 10 to 15 km for mobile and 35-40 km for fixed service with a 200mW transmitting power.
- A commercially available standard technology ensures that both network and terminal equipment are interoperable and prices for the handsets are decreasing. Valtron subsidizes the handset because the problem with CDMA450 is the price of the terminal: 150 US$ with ZTE. The price is falling to 80 US$. Different providers are available from ZTE to Chinese and Korean manufacturers.
- The broadband system can simultaneously transmit high speed data, voice and VoIP.

The broadband system can simultaneously transmit high speed data, voice and VoIP.

Services

The network has now almost 300 subscribers, the traffic is higher than estimates and the project is succeeding. Valtron has 50 employees hired from local population, most of them are technical personnel and engineers.

Callahuanca has become a technological innovation centre for technologies for rural areas. The network allows 32 rural districts in the province of Huarochirí to access to a wide range of services such as fixed wireless, mobile and public telephony, public Internet.

Valtron is also introducing Internet to residential customers.

Pricing of the service:

- Telephone: US$ 10 for fixed and mobile services for 90 minutes of phone (often customer call Valtron if they exceed the 90 minutes and Valtron and provide a credit over the phone), with $.03-$.06 for additional minutes in network and $.48 for calls to a Nextel subscriber.
- US$50 for resellers.
- Internet: public internet US$ 155 for the public internet café (normally with 6-8 computers) and they charge 60 cents US$/hour to the user. Bitrates are 256 Kbps/64 Kbps with oversubscription of

1:4 Residential Internet: US$ 20 flat fee (lowest fee from Telefonica for the same connection speed is US$ 33, 1Mbps in Lima is US$ 80, price of the satellite for the operator is US$ 4,000/MHz).

Regulation

The first constrain Ruddy Valdivia had to face was the licensing regime. The smallest license he could obtain was for the entire region of Lima and a license would involved the obligation to install no less than 5% of the number of lines available through the incumbent operator.

OSIPTEL, and the Ministry of Transportation and Communications, sponsored a law approved by the Parliament which reduced the minimum license from regional to provincial level, with no obligations regarding the number of lines installed. This law allowed Ruddy Valdivia to apply for a license and to obtain financing from the Telecom Investment fund (FITEL).

One of the conditions attached to the FITEL grant was that Ruddy Valdivia trained his locally hired staff in customer care. He decided to offer training not only to his staff, but also to potential customers such as hotels, restaurants, local companies. The reason behind this decision was that awareness of technology and service potential would induce local enterprises to use more telecommunication services.

The adopted technology required adjustments to the frequency allocation policy.

Changes were also made to the legislation regarding interconnection, which was designed for big companies.

The Rural Internet Project

In 2008 Valtron was awarded the Rural Internet Project sponsored by FITEL and targeting 1050 communities spread all over Peru.

As a mandatory requirement of the Rural Internet Project, Valtron has the obligation to provide public internet to telecenters located in the 1050 communities, but the Company's plans are for providing broadband Internet access to the residents and to the Institutions as well. CDMA 450 is again the selected technology.
Valtron will start covering 254 main communities out of the 1050 target of the project.

People running very small businesses in the areas covered by Valtron really appreciate the mobile telephony service because, due to their activities, they spend most of the day out from their villages.

In Peru people are heavy users of the internet. Families from the rural communities are always travelling to the main cities and kids get familiar with cybercafés and the internet. In many cases teachers in the schools promote the use of the Internet.
As Valtron participates in initiatives targeting the development of communities, targeted beneficiaries of the project will be residents, the numerous farmers who are trying to improve their businesses, people involved in education and kids. An example of innovative service planned by Valtron is e-learning with the customization of educational programs through the introduction of elements that have to do with everyday life, such as using mathematical equations with agricultural products from the Region.
Valtron has the ambition to develop a Technological Valley where any application and technology with the potential for bringing benefits to the community will be investigated.

Although extremely interested in introducing innovative applications supported by the network, currently Valtron has no cooperation agreements with technological parks or universities.

Lessons Learnt

- People in rural communities do not trust strangers. Valtron competes with Telefonica in the Huarochiri area, but the operator has to be perceived as part of the community to provide services successfully.
- A Telco has to offer all the services in the rural areas. Any kind of telecom service provided to the community is a successful.

9. Guatemala: The Last Mile Initiative (LMI) Project

The project

The provision model of franchising, a variant on outsourcing, has been tried in the USAid-sponsored Last Mile Initiative (LMI) Project in Guatemala. The first Micro-Telco deployment in Guatemala was in the town of Tecpan in the department of Chimaltenango. Located about an hour and a half outside of Guatemala City, the municipality of Tecpan has a population of about 58,000 with approximately 20,000 live in the present coverage area. Although DSL service is available in Tecpan, first deployed by Telgua after the start of the project, there are only about 1,600 copper lines in the municipality and of those, many are either too far from the central offices or of poor quality and therefore unable to provide broadband service. The price is also prohibitively high with a 256Kbps connection at a cost of US$49 per month.

Network technology

As the Franchise organization, the NGO Planeta En Linea (PEL), through Oportunet, the commercial name of PEL's Micro-telco franchise, contracted out most of the telecommunications infrastructure management to UNITEL, a local operator experienced in WiMax deployments. Unitel also has a 3.5GHz frequency license for WiMAX. Favorable pricing was negotiated during the project's design phase with the principal vendor Nextnet Wireless, now Motorola, primarily driven by the nature of the project as a development initiative. However, the continued relationship with Unitel has allowed PEL to access favorable volume pricing even though the units acquired have not be sizable.

Services

Through its WiMax network, Oportunet provides connectivity beginning at speeds of 64Kbps for US$12.50, 128Kbps for US$21.50, 256Kbps for US$34, and a 512Kbps connection for US$57. To put this in context, minimum wage in Guatemala is US$6.60 a day, often what amounts to a household income in a rural community.

The network has about 130 users both residential institutional (schools, court, government office). 90% of users have subscribed for the 64kbps plan priced at GTQ99 (US$12.50)
Some services available, but not yet brought online include:

- Pre-paid (pay as you go) Internet service
- On-demand speed increases
- VoIP Telephony with local number

Contextualized content was achieved through community engagement in defining, together with community leaders, priorities areas of focus. As a result, ICT's and connectivity have played a significant role and have translated into connectivity being provided at no cost to 10 locations in the community including a number of local schools, municipal government offices, health post, the court, and the police to name a few. In schools, teachers were trained not only in computer use, but in how to incorporate the Internet into their class work, either as a source for them to do research themselves, or to include research exercises as part of class work for students. As a secondary effect, much of the schools administration is now automated, reducing cumbersome paper files and expediting many critical services such as student registration.

Financing

The Micro-Telco was deployed with the support of Agexport and financing from USAID.

Regulation

Tecpan Micro-telco meets regulatory requirements because operations are managed by UNITEL-Metrovia..

Conclusions

The following elements are identified as key success factor for the project:

- In Guatemala, there is no licensing requirement. Anyone who wants to operate or provide a service, basic or non-basic, has only to register, and thereby obtain a certificate from the regulator. The process is very simple and there is no limitation on numbers (to be checked with local consultants)
- The public-private partnership
- The franchising model

Having been in full operation for little over a year, currently the Micro-telco expects a significant increase over the next few months with the introduction of more competitive pricing as mentioned above. The project has been operating as a pilot little over a year and is now well positioned to begin the process to franchise and replicate the experience in other locations.

10. Bolivia: the ACLO/IICD Project, Sopachuy

The project

Sopachuy is in the South of Bolivia in a remote location on the edges of the mountain Andes. Sopachuy is 2110 meters above sea level and four hours over unmade roads from the nearest city, Sucre. The climate is harsh, the majority of the population is Quechua farmers and does not speak Spanish which is the national language. Electricity was installed only a few years ago, telephone lines availability is limited because national telecoms never invested in adequate network facilities.

The Fundacion Accion Cultural Loyola (ACLO) and the International Institute for Communications and Development (IICD) sponsored the Sistema de Informacion Campesina- Indigena (Sopachuy) with the intention to facilitate access to important information for farmers and their associations.

The main goal of the pilot project was to achieve a proof of concept with focus on reliable connectivity at an affordable price.[18]

Network technology

After a research study in the UK, Wireless Mesh technology was selected for the network.

As part of this project, ACLO/IICD and the local community contracted LocustWorld (http://locustworld.com) that produces MeshAP, a wireless mesh networking system, to build a very simple and economical wireless network based on IEEE 802.11b technology. In two days an access network was built covering an entire town, where previously there were no telephone services. The system, which was installed and ready to work in 2 days, consists of 3 base stations each of which is a mesh box (transmitter, receiver and router) with an omni directional antenna. Of the three installed nodes, the first was connected to the Satellite with a Yagi antenna, the second was installed on the roof on the telecenter, or Internet Cafe. All of the computers in the Telecenter were connected via the mesh to the internet through a local Ethernet connection. Next door to the Telecenter are the mayor's offices. Computers in the Mayor's office were connected to the mesh using existing Ethernet, linked via a Dlink access point operating in client mode.

A third node provides future coverage for the Hospital, School, church and local co-operative, and it is intended to bring them online in stage three.

The mountainous terrain provides natural obstacles that block point to point transmissions, but also gives opportunities for bouncing the mesh signal off high nodes in prominent locations to link towns in neighboring valleys.

The base stations are linked using Mesh Wi-Fi with a maximum transmission power of 200 mW.

The transmission capacity between meshes is 2 – 3 Mbps. Like in any packet switched network the signal can take any path among the 3 nodes. Computers, IP telephones, and Xten SIP (soft) telephones are connected to the mesh boxes either via a wireless network card or Ethernet wired connection. The mesh boxes require

[18] International Telecommunication Union (ITU). *Case Study – Bolivia,* March 2007

about 4 watts of power each and are fed off a 12 – 18 volt DC source obtained from the local electricity network via an AC/DC converter or from rechargeable batteries. A PC located at the satellite station serves as the soft switch for the SIP soft telephony system used primarily as the local telephone network. The soft switch operates with Asterisk open source software. Soft telephone software can be downloaded onto local computers which are also equipped with an inexpensive microphone, speakers and/or headset. Each mesh boxes costs about US$ 500. They provide local access, infrastructure communications, voice support and comprehensive centralized network management.

The total cost of the whole system, including the Wi-Fi Mesh and the VSAT terminal antenna, associated equipment and the installation is about US$ 7,500. This kind of network can be installed by local trained technicians with simple instructions supplied by technology provider.

A wireless access point (radio and antenna) along with cabling and a terminal (IP phone) costs between US$ 100 and US$ 150. It can be mounted on a roof, and if the signal is strong enough, it can be mounted on a desk or shelf in the house.

Locust World has three network management and administration centers (two in the UK and one in the US), therefore the Wi-Fi Mesh network, not the VSAT network, can be managed either locally or remotely.

Services

Each mesh box has the capacity to serve over 100 users in a range of 2 -3 km. In practice, however, most meshes do not have that many users. The three mesh box system that was installed in Sopachuy can serve the whole of its 1,500 inhabitants.

A voice over IP telephone system was installed on the mesh, based in the Satellite control room. The system provides SIP telephony all across the mesh. Now everyone on the Sopachuy mesh can talk together on the telephone using SIP soft phones.

Financing

The pilot project was funded with funds of IICD, within IICD's Bolivian National Country Program. To sustain the pilot, money was pooled from 4 to 5 local organizations.

IICD estimates that the system operating costs are in the order of US$ 900 – 1,000/month (US$ 400 for the satellite link and US$ 500 – 600 for the other operating, administrative and staff costs).

Financial sustainability is dependent, initially at least, on 3 or 4 partners being able to pay between US$ 250 and 300 a month to support it.

The project is financed by a local agricultural producers association, Asociacion de Productores de la cuenca de Rio Milanes, and the municipal government.

Potential sources of local revenue are:

- Broadband Internet Services
- Telephony services (national and international long distance calls)
- Telecenters, where for a small fee, people are assigned voice mailboxes for messages.

Regulation

Connectivity via VSAT was bought through an ISP, resulting in a standard customer - provider relationship within the standard regulatory framework. At the time of the project there was limited to no detailed legislation with regards to the use of VOIP services. The main condition for the hardware was that it needed to be rugged and perform under extreme circumstances (cold or heat) and low energy use.

Conclusions

Participating farmers reported having experienced direct economic benefits from using the Internet services delivered via the local access network. They particularly valued information on market opportunities, production methods, use of the Internet services to promote their produce to a wider public.

The following are some of the factors that have contributed to make the project model sustainable:

- Key role of local partner organizations in negotiations with VSAT service providers
- Internet access services meeting users' needs, which were above all access to information and the capability to share it.
- A model based on pure selling of connection services in a telecenter is not able to reach long term self sustainability. A feasible option is sharing connectivity among the main actors in the community who are willing to reserve part of their budget to support the wireless community network.
- Local communities and organizations can work towards self sufficiency with training and support provided by qualified personnel, thus ensuring that the initial installation is robust, and more likely to be guaranteed a success.
- ISPS still have a stronghold on bandwidth and Quality of Service held by ISPs was a major issue during project development which revealed the need for more control exerted by Regulators in order to avoid overcharging and under-delivering.

11. Piraì Municipal Network - Brazil

The Project

Piraí is a rural municipality of about 25,000 inhabitants in the State of Rio de Janeiro, Brazil.

The Digital Piraí project was started in the late 1990s when the municipality received a small grant from the Federal Government to modernize its local tax office. At the time, the entire local government ran on two phone lines and two computers. While part of these resources were earmarked for a hybrid fixed-wireless IP network to connect various government offices, local authorities realized that broadband connectivity could be extended to a much larger area at little extra cost. Starting in 2001, the city won a number of grants and loans to develop their digital project. The municipal government formed an advisory board consisting of representatives from government, residential associations, academic and nonprofit organizations, business and labor unions to manage the project evolution and to chart a more ambitious plan that would extend wireless connectivity to much of the Piraí territory.

The project was officially launched in February 2004 (http://www.pirai.rj.gov.br). It was considered central to a plan to diversify the local economy and attract new investments following the privatization of the state-owned power utility. Integrating the ICT needs of the public sector, business and educational institutions was a major objective of the project. The emphasis is on four areas: e-government, education, public access and SME adoption. A private company with majority municipal ownership was also created to commercialize services to households and businesses

The community committee proved critical in securing partnerships with universities, NGOs, and private firms.

Network Technology

The Pirai Digital Project uses a network based on Wi-Fi technology that covers the entire city. The network serves 39 telecenters with 145 computers in public buildings; 20 telecenters in schools, with 188 computers serving over 6,000 students; and 20 access points in public libraries and other institutions with 66 computers. Each telecenter has an average of 220 users per day. The network uses free Linux software and is centrally managed. It offers Internet, E-mail, discussion groups, news, document management, e-learning, hosting, messaging and e-government services. The use of low-cost networking technologies, combined with open source software, dramatically reduced network costs, allowing Pirai to provide broadband services where traditional fixed-line operators could not justify the investment. Despite the low cost structure, funding still presented difficulties as the city could not obtain grants or loans from the central government to fund network deployment. The municipality was able to get around the lack of funding through the use of partnerships and low-cost technology. The city joined forces with local businesses possessing the required skills, and with a telecom operator that helped connect the wireless nodes. A group of universities offering online courses agreed to oversee network implementation. Innovative network management and technology choices allowed Pirai to reduce the project's costs dramatically, and made it possible to finance the project from the municipal budget, with only minor financial aid from the federal government.

Services

The project focused on four areas: (i) e-government, (ii) education (including distance education in partnership with a consortium of public universities), (iii) public access points (including training in partnership with various NGOs) (iv) services adoption by SMEs.

Financing

Funding represented both a challenge and an opportunity. Because the city found it impossible to obtain further grants from the federal government to deploy and operate the network, it was forced to seek new cooperation arrangements with civil society organizations and the private sector. The city formed partnerships with local businesses as well as a competitive telecommunications company to finance infrastructure deployment. The Pirai branch of CEDERJ, a consortium of public universities offering online courses, agreed to create an Educational Technology Center on its premises to oversee implementation and develop applications. The network was turned on in February 2004. As of May 2006, it connected all public buildings, 21 schools (including several in neighboring villages), two telecenters, and a community center.

Conclusions

The lessons from the Piraí case point to several success factors:

- The lack of public subsidies (beyond the small grant to modernize tax collection) forced local leaders to cooperative partnership arrangements with a variety of partners from private and public sectors to raise resources.
- The use of low-cost technologies (i.e., WLAN) at the transport and terminal (i.e., open-source software) layers dramatically reduced upfront costs, allowing Piraí to provide broadband services where traditional cable and xDSL operators could not justify investments.
- Good match of services with local needs thanks to local leadership, good governance which enabled collective planning and management of the project.

This deployment also provides evidence that the case for municipal networks is stronger when the local government is already providing other public services (e.g., electricity and sanitation), since economies of scope often allow provision of ICT services at minimal extra costs.

12. The Dominican Republic: Los Botados

Los Botados is a rural area of the Dominican Republic, with residential population and small businesses (agricultural sector). A pilot project started there with the deployment of a CCI center under the Rural Broadband Connectivity Project promoted by Indotel. Wi-Fi equipment was installed to bring connectivity to the local community (3000 people). Los Botados deployment has seen the participation of Viva (formerly Centennial). Viva is providing the service for free, although willingness to pay for the service has been tested with success (through cell phone service, two operators after the pilot project have installed base stations). The initiative is also strongly sponsored by the Local Authorities, especially by the Major Ramon Santos. The local municipality provides electricity and secures the equipment. Today Viva is responsible for providing repairs and maintenance as needed. The network is open and people from the community connect using PCs. Some entrepreneurial activities have emerged as a consequence: PC assemblage and Internet/Windows classes, among others. Viva plans to expand its cell phone coverage in the area and to upgrade the network if more bandwidth becomes necessary.

Following elements have proven to be critical success factors in Los Botados initiative:

- Involvement of the community, which have to feel part of the project
- Training
- Prepaid service
- Sponsorship by the local authorities

The initiative has boosted local entrepreneurship in close by villages.

Peralvillo is a rural village with residential population and small businesses close to Los Botados. Jose' Alberto Hernandez runs a Wi-Fi network there. Cell radius up to 10 km has been experienced, there's the need of improvements to the backhaul connectivity. He contracted VSAT connectivity from two different companies, but there are currently following issues with satellite connectivity: high cost, quality of the connection (due to delays, influence of the weather).

In La Yautia, a rural village close to Los Botados with a residential population of 50 families living of agriculture, two young boys who had seen the pilot project in Los Botados , started their own initiative almost one year ago by building an antenna on the top of a coconut tree to capture the Los Botados signal. The signal was too weak to support connectivity. On June 16, 2008, with Indotel support, they inaugurated a community hotspot that covers all of it and also a 5 computer training center in the local school promoted by Indotel through the CCI project. They get the Internet signal from Los Botados by a radio link.

Conclusions

Los Botados was born as a pilot project envisioned by Indotel to test the feasibility of providing a small community with broadband access.

The experience in Los Botados reveals that the major unknown variables are the estimated demand, the residents' willingness to pay, and when planning broadband services, the complementary assets represented by computers and computers training.

13. The CCI Project in the Dominican Republic

The most publicized and widespread project by the Dominican Republic Universal Service Fund (Fondo para el Desarrollo de las Telecomunicaciones-FDT) is the development of the Informatics Training Centers (Centros de Capacitación en Informática -CCI). Indotel started the CCI Project in order to provide ICT training to the population and raise the awareness of the benefits of the Internet.

Today the CCI project has achieved the deployment of 834 centers conceived to provide access to the Internet and train people of rural communities on the use of computers. The project's technological infrastructure has been funded by FDT, while sites and maintenance are provided by institutions and members of the communities.

After the initial funding by Indotel through the FDT fund, the centers are run and managed by the local community. This approach was adopted also in order to promote the local entrepreneurial spirit.
Centers have sponsors from the communities (business and farmers associations, NGO's, religious institutions, senators, majors) and management comities. Those groups take responsibility of the administration of the centers, electricity supply and the sustainability of operations on the long run.
Following services are provided by the CCI Telecenters: Internet access, telemedicine, special training courses. Services are free of charge and limited to a certain time. Classes are taught by members of the same communities trained at the ITLA (Instituto Tecnológico de las Américas), the government training and technological center located near Santo Domingo. Under this project, people have the opportunity to learn for free the use of the Internet.

Centers operate with funds donated by the sponsors and also raised by locals through different activities which may include using the premises to project movies on weekends.

Since CCI's are located in rural areas not all centers have Internet access and those which are connected use different technologies: DSL, Wi-Fi and VSAT.

Part of the Rural Connectivity Program is to provide Internet access to CCI's. 800 CCI centers out of 1000 have been installed, some lack the Internet connectivity.

Training at the CCI's is currently limited to basic expertise, but in April 2009 a project will start for ICT capacity building. According to the plans, a number of people in the range from 2000 to 4000 will receive courses in hardware maintenance and assembling, software for webpages masters, capacity building for small entrepreneurship.

The role of the NGOs has proven fundamental in operating the CCI centers. World Vision is an NGO currently working in eight provinces of the Dominican Republic: Independencia, Barahona, Bahoruco, El Seybo, San Cristobal (Villa Altagracia), Santo Domingo Norte (Sábana Perdida), Elias Piña, Dajabón and, among the others, is strongly committed to the support of CCIs. There are 28 CCIs in these provinces. Sur Futuro is a Dominican NGO operating the CCI centers in three communities and sponsoring the CCIs in four communities out of the 134 where they're active.

14. Rural Connectivity via WiMAX in the Dominican Republic

BecTel is a Dominican operator who has entered in past years into a partnership agreement with BEC Telecom, S.A. (BEC-TEL) to provide remote rural and urban communities in the Dominican Republic with convenient, cost- effective access to telecommunication services through the deployment of a wireless public payphone system.

BEC-TEL was awarded a contract by the Dominican government to deliver and install more than 1,700 latest generation wireless payphones in rural areas of the Dominican Republic underserved by wireless and landline phone systems. Through its telecommunications switching facilities in the United States and the Dominican Republic, Tricom provides the origination, transport and termination of local, domestic and international long distance traffic. The access network is a CDMA cellular and is owned by Tricom. BecTel is a sort of VNO. Currently, there are 1,750 public telephones in service. The customers buy calling cards from nearby "colmados" (convenience stores) and can make local or international calls from the phones.
WiMAX technology supports a 20-25% of the whole network. (3.6 GHz frequency band) supporting Bec-Tel operations. Backhaul is microwave (5.3GHz)

Two towns were selected for the WiMAX service with the aim of testing the success of the initiative in two completely different environments :

- Bavaro, touristic area in the 'Golden Corridor'
- Los Cacaos, rural area, with no mobile coverage, no fixed telephony

Service started in May 2008. Delivered services are VoIP and broadband Internet (classes of services with different QoS are supported by the network). In Los Cacaos there are 10 customers for the Internet and 50 customers for voice. The situation is different in Bavaro, where there are 300 customers for the Internet and 50 for voice.

Technology is fixed WiMAX from Alvarion using their 3.5 GHz equipment.

<u>According to Bec-Tel experience, main critical factors for the deployment of local broadband access networks in rural areas can be identified in:</u>

- Electricity (three day power shortages may happen in rural areas)
- A twenty year old Telecommunications law which needs changes
- Access to the fiber optic is a major entry barrier. The signaling has to be SS7 which requires buying a lot of hardware
- Smaller companies need subsidiary services to move money from one service to the other because they do not reach sufficient volumes.
- Access to the credit, with a difficult bids to gain the access to USF/UAF
- Financing: no private financing. High investments are required in a highly competitive, technology driven environment. VC and PE in the Dominican Republic are too small and mainly oriented to tourism and industries with higher guarantees. It is almost impossible to obtain credit from the banks, as there's nothing which can cover the loan if the project fails.

Bec-Tel is currently receiving funds of Indotel for the deployment of public telephony, whereas the services delivered via the WiMAX networks are subsidized by the revenues of the public telephony business.

Bec-Tel experience highlights the following elements as critical success factors for the sustainability :

- Costs for sales and management

- Billing and collection of money from the service BecTel is considering the franchise model
- Educational level (as an example, at the Customer Service in Los Botados there's still people asking how to dial the telephone number)
- No contract for the residential users in rural (remote and non remote areas) prepaid is mandatory
- It's required to create the need for the Internet. The most valuable services are still voice and video (TV). In Salinas, for example, most of the people wanted the Internet service and there was no request for the Internet at the beginning. Now ten people have the Internet there.
- Affordability of the internet service: people are very receptive and the kids want the internet service, but the affordability for the families may be a major issue
- Qualified people for running the sales: BecTel operates with people from Israel who have developed smart software solution to keep track of the sales via GSM/GPRS .

15. Mobile WiMAX in the Dominican Republic

At the beginning of 2008, Tricom, one of the Dominican Republic's leading carriers, has awarded Airspan, a leading provider of WiMAX and Wi-Fi based broadband wireless access networks, a contract to supply WiMAX equipment in the licensed 3.5GHz frequency band in order to expand their network.

Tricom is a full service provider and one of the largest data providers in the Dominican Republic, offering a wide range of fixed, mobile and paid TV services throughout the country. Tricom's WiMAX network will support a full range of high-end broadband data offerings and next generation applications.

The network will support 802.16e-2005 Mobile WiMAX services in both indoor and outdoor base station configurations. During the first phase of the network rollout, Tricom will offer services in the Santo Domingo metropolitan area, Bavaro, Haina, and Santiago.

During the month of July 2008, 155 mayors across the Dominican Republic, were invited to participate to a kick off meeting for the launch of the "Dominican Republic's Digital Cities Project (Electronic Municipal Government)".

The call was made by the Latin American Association of Research Centers and Telecommunications Companies (AHCIET), the Dominican Telecommunications Institute (Indotel) and the Presidential Office for Information and Communication Technologies (OPTIC).

The invitation, signed by Indotel president Jose Rafael Vargas, and OPTIC director Domingo Tavárez, marks the start of the cooperation agreement between AHCIET and their agencies, which will allow each municipality to become Digital City, with connectivity, access, information and services available for their inhabitants.

16. U.S.A. - Successful Partnership in Allegany County

The project

In 2001, Allegany County concluded that its economic future depends heavily on the ability to offer business and residential users carrier-class broadband services. Unsatisfied by the spotty and slow pace of private carrier broadband deployments and facing the prospect of investing millions of dollars to deploy fiber, the county sought alternative solutions.

Allegany County decided to deploy a wireless local broadband network to provide high speed internet access to the County's government buildings, schools and libraries.

Network technology

The network uses pre-standard WiMAX equipment.

Services

The county manages the network, but has granted local Internet Service Providers access to offer broadband services to the County's residences and businesses.

As a result, the network provides government agencies and the community with new and legacy telecommunications services.

Today the network provides high speed Internet Access and Internet Protocol Telephony to Allegany County's government buildings.

The county streams video of government meetings on the web. Law enforcement officers can access regional incident reporting system and national crime database from their patrol cars.

Overall the County government saves US$ 160,000 a year, while the country school district saves US$ 400,000 in telecommunications spending per year.

Other subscribers to the network include local towns, cities, state and regional government agencies and nonprofit organizations. These subscribers pay a nominal US$ 420 annual fee.

Financing

The county built its US$ 4.7 million WiMAX network in partnership with Allegany County Public Schools, the Allegany County Library system and the city of Cumberland.

The four entities pooled their IT expertise and received grants from the Appalachian Regional Commission, the state and the federal government to build the wireless network covering 525 miles of the mostly rural county in the west corner of Maryland.

The alternative was spending US$ 680 million to build a fiber optic communications network to meet the community's needs. The core of the network, called AllCoNet2, features 16 wireless radio towers supporting Asynchronous Transfer Mode, Ethernet and other broadband services.

Regulation

Civic leaders formed AllCoNet as a self-operated municipal carrier to deploy wireless broadband solutions using both 6 GHz licensed frequency bands for a point-to-point ring around the network as well as unlicensed frequency bands for point-to-multipoint to offer reliable, cost-effective broadband connections.

Conclusions

While fiber would have provided more capacity, wireless broadband allowed Allegany County to achieve near complete coverage of their rural and mountainous county with the same carrier grade of access services as we could with fiber, but at a fraction of the cost.

17. Wireless Minneapolis – U.S.A.

The project[19]

Beginning in 2004, a team of Minneapolis City technology experts worked with representatives from business, education, nonprofits, and the community to examine the business case for deploying a wireless broadband local access network and to define Minneapolis City government's business needs, costs, funding options, trends and technology. The project saw stakeholder's involvement from its initial phase. Through this analysis and stakeholders' input, the City determined that a public-private partnership was the most cost-effective and serviceable approach.

The City began an extensive RFP process and evaluated the proposals submitted with input from community, business and resident stakeholders and government partners.

In 2006 the City of Minneapolis signed a 10-year contract with USI Wireless, a private company based in of Minnetonka, to provide Minneapolis with a citywide wireless broadband network. USI Wireless will own, build and manage the wireless network.

USI Wireless is completing construction in six geographic phases. When completed, the wireless network will cover all 59 square miles of Minneapolis providing residents, businesses and visitors with wireless broadband access anywhere in the City (http://www.ci.minneapolis.mn.us/wirelessminneapolis/).

Network technology

US Internet built the metro-wide network using BelAir200 and BelAir100 nodes. The BelAir200 units are four-radio wireless switch routers with an access radio module that uses 2.4 GHz Wi-Fi and can also be configured with up to three separate 5 GHz backhaul radios. The BelAir100 is a two-radio node that accepts the same radio modules as the BelAir200.

Services

As part of the contract, US Internet is providing a comprehensive set of community benefits that goes far beyond what any other city in the country has negotiated.

USI Wireless will provide $500,000 to create a "digital inclusion fund" that will be used to promote affordable Internet access, low-cost hardware, local content and training. In addition, US Internet will direct a minimum of five percent of the network's net profits to a digital inclusion fund for ongoing digital inclusion efforts. In total, it is expected that about $11 million will go into the digital inclusion fund over the 10-year term of the contract.

Free limited-time service will be available in some public locations. A free "walled garden" level of wireless service will be available to people throughout the city for important neighborhood, government, and community services information. Designated community technology centers will receive free wireless access.

The community benefits package was created with strong input and feedback from the community. In partnership with C-CAN (a non-profit network of local organizations using technology to serve their communities), a Digital Inclusion Task Force received public comments and feedback about what community benefits are important to help bridge the digital divide. Based on that input, the task force created a

[19] The analysis is taken from http://www.startribune.com/science/26884744.html?elr=KArks:DCiUo3PD:3D_V_qD3L:c7cQKUiD3aPc:_Yyc:aUU

Community Benefits report that served as a basis for Wireless Minneapolis contract negotiations with US Internet.

Financing

USI Wireless, the private partner, will fund, build, own, and manage the wireless network upon the City's existing fiber optic network. In addition, USI Wireless will also retail the service. The City, the public partner, will own the fiber and serve as an anchor tenant for network services. The City has committed to the payment of an US$ 1.25 million annual fee as anchor tenant for wireless service usage. This represents a savings over the City's current Internet costs and an effective opportunity for city's mobile workforce dispatched on territory.

The City will allow the private partner to use City its facilities including buildings, light poles, traffic signals and other assets to mount wireless equipment throughout the city's 59 square miles area. The private partner will fund, build and operate the wholesale and retail wireless network.

The network will be made available to residents, business and visitors. USI Wireless will pay a fee to use City assets and will retail the service.

USI wireless will provide ubiquitous outdoor municipal, commercial, residential and roaming wireless broadband coverage and 90 percent indoor coverage for multi-family and high rise residential units at speeds of one to three megabits per second.

Some have questioned the Minneapolis, MN, business model as being an anomaly in regards to large scale municipal wireless deployments, based on the fact that the municipal revenue commitment of $1.25 mln per year represents 124 percent of the total deployment costs[20]. However, it appears that the authors of this analysis do not take into account the fact that the City decided that the $1.25 mln investment represented a cost savings over previous Internet access that they were receiving. In addition, as discussed later in Section 3.1, it is municipal financial commitments that have been the key to success with regards to municipal projects. None of the other cities cited in the analysis made any financial commitments, and thus their projects have gone nowhere. Minneapolis has and they are experiencing success.

Regulation

The network operates in the 2.4 GHz unlicensed frequency band.

Conclusions

As of August 2008, the network has 10,000 users and has reached the break-even point, according to a story in the Minneapolis Star Tribune.

[20] See Civitium's analysis (http://www.civitium.com/Civitium-MBMA-Report.pdf), page 8.

18. Racine County Wi-Fi Network

The Project

Racine County lies between Milwaukee and Chicago, and much of its area has been ignored by telecom incumbents and cable operators because sparsely populated.

The county decided to partner with Evergent, an ISP, to provide fixed wireless (point-to-point) access to subscribers in those areas.

The county **convinced the townships to rent out space on township assets** (e.g. water towers) at less than cellular rates. The county did an extensive study and worked early on with the communities (17 in total) to ensure that the business model for the ISP works. At first townships wanted to rent out space on towers at the rate that they charged cellular operators, but the county convinced them that this type of service (fixed wireless broadband) is different and that the rates that the townships wanted to impose were unreasonable. People in the townships want broadband desperately and part of creating good economic base in the townships is having broadband service.

Network technology

The network uses Midwest Fiber's network for backhaul and Wi-Fi technology for the access network.. At present, they have 550 customers and cover 65-70% of the county (including the city of Racine as well as the communities of Raymond, Caledonia, Sturdevant, Waterford, Burlington and Mt. Pleasant. Evergent is expanding service to other parts of the county.[21]

Financing

County Executives have been talking about the project to build support.

Since there was a tax hike moratorium (levy freeze) in the County, the County was not able to make any financial commitments to the network. However, it assisted the ISP in securing space on water towers and other facilities reduced rate. The County and ISP also focused on providing broadband service in the rural areas of the County that currently have one or no broadband options.

Regulation

The network uses 2.4 GHz license-exempt frequency band.

Conclusions

Racine Count project is not the typical Wi-Fi project, where the city or county officials plan to give free Wi-Fi to needy people or to "digital nomads". The Racine County project wanted to address specifically the lack of broadband in large areas of the county that have been ignored by the telecom incumbents and cable operators.

This focused service planning is regarded as the main success factor for the project.

[21] http://www.muniwireless.com/2008/05/04/racine-county-wifi-providing-access-where-needed/)

19. Wireless Broadband Internet in Ta Van, Vietnam

The project[22]

Beginning in 2006, Intel, the United States Agency for International Development (USAID), and the Vietnam Data Communication Company (VDC) formed a public-private partnership in a joint effort to introduce WiMAX networks into Vietnam. This partnership included the delivery of broadband access to the village of Ta Van in Lào Cai province located in north-west Vietnam. Ta Van is a remote village two hours away from Lào Cai city and near the mountain town of Sapa. Ta Van village has only two fixed-line phones, limited mobile phone coverage and no Internet access.

The primary focus of the joint Intel, USAID and VDC project was to demonstrate that it is both technically and economically feasible to bring broadband Internet access to remote regions using commercially available wireless Internet Protocol (IP) technology. The project was deployed in two phases. The first phase used WiMAX technology linked to a fiber-optic backhaul to bring broadband Internet access and Voice over IP (VoIP) services to residents of Lào Cai city in north-west Vietnam. The second phase of the project was deployed in Ta Van, and used a backhaul broadband satellite connection, in combination with WiMAX and Wi-Fi technology. This solution was successful in providing broadband Internet access and telephony service to the whole village.

Network technology

Deployment of traditional wired broadband technologies (DSL, cable, fiber) in the village of Ta Van, was economically unfeasible, due to the lack of infrastructure. WiMAX was the selected technology for the wireless broadband access network.

While point to point wireless backhaul solutions such as microwave are often cost ineffective, backhaul based on satellite have higher operational cost which make it a cost-prohibitive solution. Recent deployment of new satellites deliver dedicated IP bandwidth at reasonable cost.

The adopted solution for backhaul in the Ta Van project is based on IPSTAR satellite, which delivers pure IP bandwidth to the Asia-Pacific region by using the latest modulation and beam-forming technologies. The broadband satellite's overall bandwidth capacity is 45 Gbps and it can provide a bandwidth of up to 4 Mbps down and 2 Mbps up to an individual end user location. A shared 2Mbps down and 512kbps uplink from IPSTAR was used as the satellite backhaul at Ta Van. This was connected to a WiMAX network consisting of a single base station which delivers broadband connectivity to multiple users at the village. The network didn't pose any particular requirement in terms of civil infrastructure and no climate-controlled environment to house both the satellite and WiMAX equipment.

The IPSTAR satellite system requires only one Very Small Aperture Terminal (VSAT) satellite dish and a small indoor user terminal. Deployed WiMAX BS were available in small form factors for outdoor installation. For example, the deployed base station contains all the necessary radio and electronic circuitry in one compact outdoor unit, only requiring one small indoor unit for switching and power.

As the IPSTAR satellite provides limited backhaul, the objective of the network architecture was to provide WiMAX coverage in a cost-effective manner. Hence, a single omni-directional antenna was deployed to provide

[22] Intel, 2007 *Cost-effective Rural Broadband: A Vietnam Case Study*

good coverage over several kilometers in Line of Sight (LOS) conditions. Combination of WiMAX and IPSTAR increases the economic viability of such a deployment in rural areas.

The following components are installed outdoor at the base station location:

- A VSAT antenna
- An omni-directional antenna
- One WiMAX base station
- A Lightning protector

The following components of the base station are deployed indoor without the need for air-conditioning:

- The satellite user terminal
- The indoor unit of the Airspan MicroMAX base station
- An Edgewater Networks multi-function network appliance

The equipment is very compact and has minimal power requirements, and can be deployed in very rudimentary environments. The Ta Van project was designed as a proof of concept with limited operational resources. It has demonstrated also the importance of operational support from a reliable backend infrastructure and components such as the media gateway and the soft switch server in the production environment to ensure reliable service and good audio quality.

In any satellite deployment, as backhaul bandwidth is limited and expensive, user training is crucial in avoiding bandwidth intensive activities. At Ta Van, the strong community network allowed users to be educated on how to avoid bandwidth intensive applications such as video streaming or P2P traffic. Besides education, the WiMAX network is configured to limit the bandwidth of each SS. This prevented any single user from taking up the entire satellite bandwidth.

Quality of Service was a major issue in network deployment, as an inherent limitation of geo-synchronous satellites is latency. That is the time it takes for a signal to cover the distance from the user station to the satellite and then to the satellite gateway. In addition to this limitation, WiMAX and Wi-Fi networks introduce additional delays. Overall latencies of 580ms to over 1,000ms roundtrip were observed. For normal Internet activity this latency is not noticeable. However, for VoIP services, latency can be a significant issue. Though it is generally assumed that latency of over 500ms makes a normal voice conversation difficult, latency was not found to be an issue. In the deployment, QoS was implemented on the Edgewater Networks device for VoIP as well as on the satellite gateway. The audio quality ranged from acceptable to excellent.

Two types of subscriber stations (SS) were deployed in user locations:

- the basic SS providing a single Ethernet connection, which is connected to a switch or a Wi-Fi access point to provide indoor connectivity.
- the SS integrated with Wi-Fi providing the same wired Ethernet connection but also integrating a Wi-Fi access point into the same chassis.

Thus, WiMAX provides the last mile access, while Wi-Fi provides the last meter access. Furthermore, an integrated unit provides good outdoor Wi-Fi coverage that can be utilized for Wi-Fi bridges.

One of the current challenges of WiMAX is the high cost of SS which is expected to decrease with the start of scale economies made possible by technology adoption and by the Standardization activity which favors interoperability of equipment from different vendors. In the meantime, the high cost of the SS tends to inhibit the mass-deployment of WiMAX networks in rural areas. However, in the Ta Van project, although a temporary solution, one SS could deliver broadband connectivity to several end-users. An integrated Wi-Fi SS was mounted in a suitable outdoor location. Using outdoor Ethernet wires and Wi-Fi bridges, multiple households were connected to the single SS. A Wi-Fi bridge receives a Wi-Fi signal, distributing it via the built-in switching capability. The following **Figure** illustrates how this shared architecture was achieved at Ta Van village.

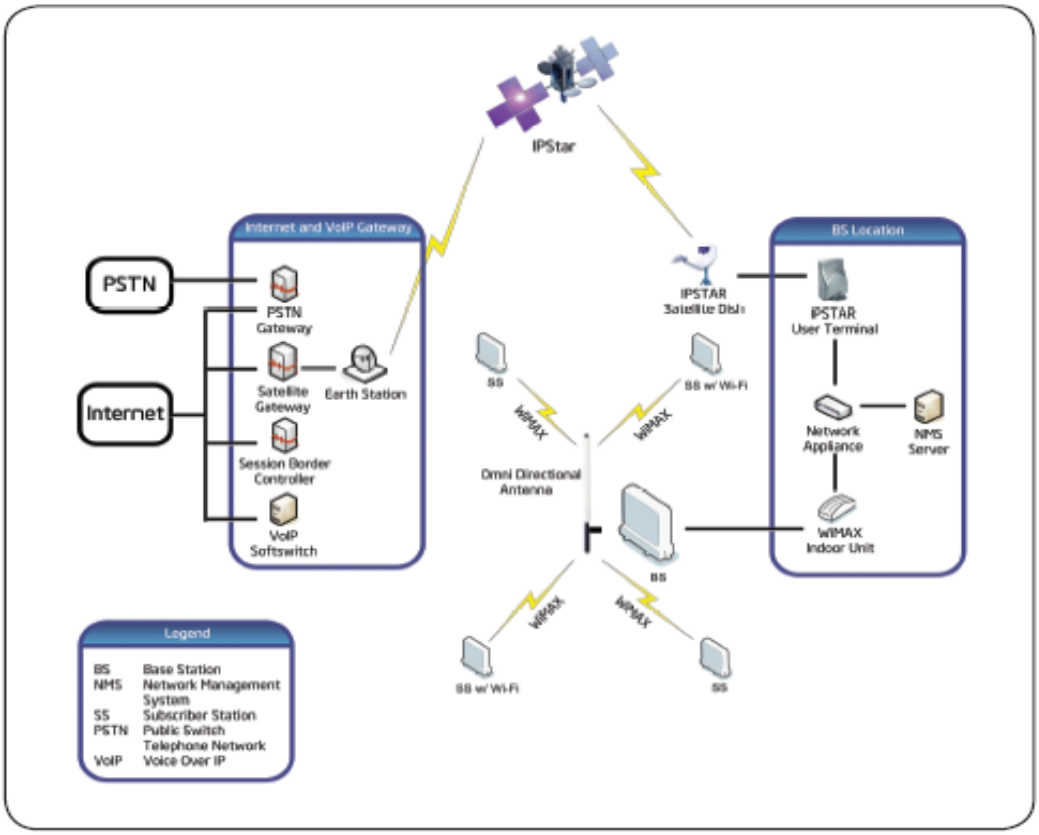


Figure : Network architecture at Ta Van village, Vietnam[23]

One of the key objectives of the Ta Van project was to demonstrate that it is economically feasible to deliver broadband connectivity to even the most remote rural area using commercially available equipment.

We briefly summarize in the following the network costs.

- **Capital Expenditure.** A wireless network designed to support an estimated 40 end-users, similar to what has been deployed in Ta Van can be delivered for less than US$20,000 at current prices. The

[23] Source: Intel, 2007 *Cost-effective Rural Broadband: A Vietnam Case Study*

base station equipment is the main component. Its cost is about USD $12,000. This includes: the cost of the actual WiMAX base station for $6,000, equipment such as the antenna, lightening protection, network device, satellite equipment and miscellaneous items. It does not cover the costs of any associated structural work. If a combination of WiMAX subscriber stations, Wi-Fi bridges and outdoor Ethernet cables are used to connect 4-5 users to each subscriber station, the cost per user is projected to be $200 each to connect 40 end-user locations for a total of about $8,000.

- **Operating Expenditure.** The cost of the satellite connection is the primary deciding factor for this model. The cost of a traditional satellite solution is often prohibitively expensive. However, IP-based satellites such as IPSTAR provide broadband connectivity at a lower price. Other factors influencing the pricing are represented by the in-country cost of connecting to the Internet and operational costs. Thus, the cost of delivering Internet connectivity not only depends on the satellite technology but also on the country it is delivered to. Furthermore, broadband satellites rely on an over-subscription approach. This occurs where a single link is shared across several users based on the assumption that only a subset of users accesses the Internet at the same time. This is also known as the sharing ratio. A lower sharing ratio means better overall connectivity, but results in a higher cost. Thus, the cost for satellite backhaul varies greatly depending on the above mentioned factors.

In addition, our observations indicate that Internet access is more important to rural areas such as Ta Van. This is due to the fact that alternatives for news, communications and entertainment are limited, and thus the Internet provides a lifeline otherwise not available elsewhere.

A 2 Mbps down, 512 kbps up link can support more than 40 users, assuming a reasonable satellite sharing ratio is used. With a range of $1,000 to $ 1,600 for 1 Mbps of satellite link, broadband Internet including VoIP can be delivered for a monthly cost ranging from $25 to $40 per household.

It should be emphasized that if other forms of backhaul such as fiber or wireless backhaul are utilized, the operational expenditure for backhaul will be reduced dramatically due to the higher capacity and lower running cost of these solutions compared to satellite. (see [8] for more details)

Services

The network supports both VoIP and broadband – based Internet services.

Financing

Intel, the United States Agency for International Development (USAID), and the Vietnam Data Communication Company (VDC) formed a public-private partnership to finance the project. Some elements during the business case development were identified as critical in order to achieve a financially-sustainable business model. These include:

- gathering the provision of high-demand services (voice, data) in order to capture the maximum amount of business possible from the rural community, gain maximum benefits from the economies of scale and scope through the central pooled resources that can support hundreds of communities,
- minimize the demand for technical support required at the community level, with the result of improving service and lowering support costs.
- use of pre-paid tariffs

Regulation

The network operates on unlicensed frequency bands.

Conclusions

The Ta Van project had three major objectives: (i) demonstrate the technology; (ii) develop a cost model for effective sustainability; (iii) showcase the benefits of broadband Internet access to rural areas. How issues under (i) and (ii) were met is broadly described above in previous sections.

Feedback on the positive adoption of broadband based services was encouraging. Ta Van residents took to the Internet quickly. The village residents' use of the Internet and VoIP is higher than expected, with daily usage for the existing 12 locations often exceeding 500MB.Residents use the Internet and VoIP to communicate with people in other parts of Vietnam. For many users in Ta Van, the Internet is also the primary source of news because other sources of news such newspapers are limited due to the remoteness of the village. The nurses at the local health station use the Internet to search for medical and pharmaceutical information. A national agricultural institute conducted an informal workshop in one farmer's house to show other farmers on how to use the Internet to find crop disease information. Tourists staying at the guest house, can use the Internet to send e-mail, update their travel blogs, and upload photos. Tourist guides use e-mail to communicate with their clients and to get referrals, hence increasing their business.

The project demonstrated the feasibility of deploying sustainable local broadband access networks in remote areas where only rudimentary infrastructure exists.

Many countries have started to extend their universal service funds (USF) to cover not only voice communications but also data communications in rural areas. As this deployment model provides both voice and data communications, it is an ideal vehicle to achieve the objectives set by USFs.

20. The Djurslands.net project in Denmark

The project

The DjurslandS.net network was established to provide services to Djursland, an area in Denmark that is primarily rural. It is an interesting example of voluntary networks, where groups of people within a community work together towards providing high-speed Internet access. Djurslands.net is considered one of the biggest non-commercial rural wireless Internet network in the world, it runs at about a third of the cost it takes to run a similar project in the urban areas and it is run solely by volunteers in the several hundred villages across Djursland.

The major issue in Djursland was that although the area is served with DSL service, the sparseness of population made this region unattractive and difficult for commercial telecom operators to provide broadband connectivity. Due to the lack of adequate internet connections, the economy of this region was facing collective collapse.

Network technology

DjurslandS.net is based on an Internet connected optical fiber ring all around Djursland; bandwidth is rented from commercial Internet Service Providers. Each of the now ten community networks on Djursland has access to this optical fiber ring in their biggest village, but as a cabled network all the way to the homes is expensive, the bandwidth is spread out wirelessly -- point to point -- by directional antenna links that are placed on towers, silos or high buildings in the central villages. From there it is again wirelessly spread - point to point - by directional antennas pointing in different directions to more distant villages. This splitting structure is repeated several times until all villages get their wireless backbone connection.

From each of these connection points of this web infrastructure, the bandwidth is then spread locally by omni directional antennas to directional antennas on the roofs of the houses (point to multipoint connection).

At every single end of each of all the connections cheap wireless standard access-points, based on the IEEE 802.11 a, b, g and n standards are deployed. These all use free and unlicensed frequencies and as most of the access points are for indoor use.

To become a user in one of the community networks on Djursland, a household pays an affordable starting fee which is used to buy equipment for the infrastructure and the users gear. The broadband access payable to the ISPs is shared by all the member households, so that each member can get unlimited fulltime access for a cheap monthly fee.

Services

The network delivers residential and business Internet services. To become a user in one of the community networks on Djursland, a household pays an affordable starting fee which is used to buy user equipment. The broadband access payable to the ISPs is shared by all the member households, so that each member can get unlimited fulltime access for a cheap monthly fee.

Financing

The network was financed and is currently operated by local volunteers.

Regulation

The network uses free and unlicensed frequencies.

Conclusions

The team of volunteers has also set up the Djursland International Institute of Rural Wireless Broadband" (DIIRWB) in order to share the lessons learned during the establishing, building and running of the DjurslandS.net project.

The entire case study is available on the OPLAN/InfoDev website.

21. The Millennium Villages (Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania and Uganda)[24]

The project

The Millennium Villages project, based at The Earth Institute at Columbia University, is a science-based bottom-up approach to lifting rural villages out of the poverty trap that afflicts more than a billion people worldwide. The community-driven initiative currently operates in 10 sub-Saharan African countries where it tackles challenges related to health, education, nutrition, livelihoods, gender equality and other vital issues

The first Millennium Village was started in Sauri, Kenya in August 2004 and saw remarkable results in just two years. For example, the villagers went from chronic hunger to a tripling of their crop production. Also, for the first time in years, they were able to sell their produce in nearby markets. The second Millennium Village was launched in Koraro, Ethiopia in February 2005 and also saw tremendous progress early on.

With the financial support from the Government of Japan, an additional ten villages were implemented in partnership with UNDP and the Earth Institute at Columbia University, creating a total of 12 Millennium Villages located in the following countries: Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania and Uganda. The areas were selected to represent each of the agro-ecological zones in Sub-Saharan Africa. These agro- ecological zones are representative of 93 percent of the agricultural land area in sub-Saharan Africa and the homes of 90 percent of the agriculture population. Each Millennium Village is located in a reasonably well-governed and stable country and in a hunger hotspot, an area with the highest rates of rural poverty and hunger as identified by the UN Millennium Project.

The leading 2G and 3G equipment manufacturer Ericsson, has partnered with mobile operator Zain and The Earth Institute to provide Dertu (Kenya), Ruhiira (Uganda), Mbola (Tanzania) energy efficient mobile connectivity that enables voice and data calls helping with family health, local commerce and even livestock tracking.

Dertu is situated in the northern part of Kenya, 100 km north of Garissa, close to Somali border. It spreads on area of 750 square kilometers with a total population of just over 5,200, mainly pastoral and nomadic society. Until recently, Dertu in Northern Kenya never had telecoms of any kind.

Uganda's Ruhiira Millennium Village cluster is situated south from Mbarbara on 338 square kilometers with a population of over 43,000. The hilly terrain and poor roads and communication systems make transport in Ruhiira exceptionally difficult.

Tanzania's Mbola cluster is about 20 communities spread out over 700 square kilometers with a total population of 30,000. Located in the Uyui district in mid-western Tanzania. The nearest city center is Tabora which is located 36 km away.

Ericsson and Zain (through its wholly-owned African subsidiary Celtel) have teamed up to develop a comprehensive end-to-end telecommunication strategy in the villages and to drive mobile phone connectivity and coverage build-out to selected areas.

[24] Source: Millennium Villages official site http://www.millenniumvillages.org/

Network Technology

Network relies on standard EDGE technology. In October 2007, the temporary network started to be replaced by a permanent one still operated by Zain. The permanent solution uses Ericsson's sustainable energy solutions including wind, solar energy and other solutions to drive equipment at minimum power requirements. It is estimated that the permanent solution will run at 80% increased efficiency over traditional diesel-powered mobile sites.

Services

A temporary mobile network provided service to 5,000 people in Dertu for the first time. Sony Ericsson has supplied mobile handsets to the health clinics and community health workers. Together with Ericsson, they have developed a new *Solar Village Charger* that is capable of re-charging 30 mobile phone batteries each day and eight phones simultaneously for each village cluster. In Tanzania and Uganda, Ericsson has upgraded Zain's GSM network to EDGE and at the same time improved coverage and network reach. Using a combination of 'fixed-wireless terminals' mobile Internet connectivity will be provided to schools and health centers. Plans are also in-place to extend coverage to all 73,000 people in both village clusters. Sony Ericsson and Ericsson also have provided handsets to community and health workers and piloted new healthcare applications for mobile learning purposes as well as basic household data collection Zain has provided SIM cards and established emergency numbers to improve access to healthcare and emergency services. Zain will also provide a toll-free number that can be used in medical emergencies to connect patients with on-duty medical personnel. Other initiatives include a mobile learning tool to train community health workers and mobile applications to collect and share basic household data and health information.

Financing

The project was sponsored by the Government of Japan, UNDP and the Earth Institute at Columbia University.

Regulation

Zain (www.zain.com) is a mobile operator holding licenses for operating in following countries: Kuwait, Bahrain, Iraq, Jordan, Sudan.

In Africa, Zain operates under the Celtel brand (www.celtel.com) in 14 sub-Saharan African countries namely: Burkina Faso, Chad, Democratic Republic of the Congo, Republic of the Congo, Gabon, Kenya, Malawi, Madagascar, Niger, Nigeria, Sierra Leone, Tanzania, Uganda and Zambia. The company's mobile telecommunications operations in Ghana will start in 2008.

Conclusions

To scale up the project, additional Millennium Villages are being implemented in clusters around the original Millennium Villages. These Villages are financed by Millennium Promise, a non-profit organization founded to help achieve the Millennium Development Goals by 2015, and implemented in partnership with UNDP and other partner organizations.

The scaling up of Millennium Villages has four core objectives:

- **Scaling-up:** to provide integrated village-level interventions across an entire district, or substantial parts thereof, applying lessons from Millennium Villages while still operating within the external financing envelope established through existing international agreements.
- **Lessons for district-wide and national scaling up:** to understand and demonstrate how community-based interventions for achieving the Millennium Development Goals can be coordinated,

implemented, and financed at the district scale and which national mechanisms are needed to support district-level activities.

- **Lessons for district-level interventions:** to understand which interventions need to be provided at a district level (e.g. referral hospitals, transport infrastructure, electricity generation and distribution) and demonstrate how they can be scaled up.
- **Donor mobilization:** to engage public and private donors in practical, results-based, monitored and measured interventions at the village and district level.

ANNEX 3 - INVENTORY OF LOCAL BROADBAND ACCESS NETWORKS IN BRAZIL, DOMINICAN REPUBLIC, GUATEMALA AND PERU

Brazil

Name of project	Location	Private Sponsors	Public Sponsors	Description
Amazonas Digital	State of Amazonas	-	State of Amazonas, Federal government and municipalities	61 of 62 municipalities of Amazonas will receive wireless networks to access the Internet, this is what the project Amazonas Digital promises, whose bid has been made (won by Hughes) and is currently in the process of signing the contract. Manaus is out, as will need a more complex network. The wireless internet signal will be relayed via satellite and via Wi-Fi or WiMAX, depends on each case. The 15 municipalities of the first phase are: Barcelos; Boca do Acre; Carauari; Coari; Eirunepé; Humaitá; Itacoatiara; Japurá; Manacapuru; Manicoré; Maués; Parintins; São Gabriel da Cachoeira; Tabatinga e Tefé.
Barbacena Digital	Barbacena, MG	Damovo	* Ministry of Communications, * University of Ouro Preto, * National Network of Education and Research (RNP), * Foundation for Educational Radio and Television of Ouro Preto (FEOP)	RNP and Damovo implemented the Digital City project in Barbacena, Minas Gerais, home of the Minister of Communications, Hélio Costa. The initiative belongs to the digital inclusion program of the Federal Government. After Tiradentes, Barbacena is the next city to have wireless connection and access the Internet in all its schools and health clinics. In total, 54 places have technology for converged communications, with which the population has access to packages of voice, video and data.
Brasilia Digital	Brasília, DF	-	Local and Federal government	The project includes the installation of a wireless internet network throughout the federal capital. These are the plans of the Government of the Federal District, in an initiative coordinated by Department of Science and Technology. The goal is to build a public wireless network, including the currently secretariats' network, starting with Public Safety, Education, Health and Finance. The project will be implemented in five stages. The first is the placement of the backbone. The following address to make the connection, every two or three months, in other cities in the DF. The intention is that, until December 2009, already implemented 40% to 60% of the project. The schedule is full until June 2010. Access will be free and can be done from anywhere, including homes.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Cidade Digital - Bauru	Bauru, SP	-	Local government	The city of Bauru is investing in projects of Digital City for the adoption of public policies. The initiatives, which began to be developed in 2005, include the interconnection of administrative units, a network of fiber optics and other wireless, computerization of services for the citizen and the recent implementation of a Infocenters. The units located in the municipal district of Tibiriçá were connected to the municipal headquarters. The expectation is that other activities can be implemented in 2009 and that the network includes services in all health units and education.
Cidade Digital - Camaçari	Camaçari, BA	-	Local government	The project was conceived and initiated in 2006, and was expected to be completed in stages. The first initiative was the revision of data networks and electrical properties of the school. In the educational units were installing laboratories for robotics, smart tables and digital boards. The next step was the monitoring of public roads, from a system with 22 IP cameras. Now the ongoing second phase of the project, with the expansion of the coverage area for all other school units hitherto missed. The goal is for all 90 municipal schools have access to the Internet and education systems. The last stage of the project will be free Internet access for the population, due at the end of 2009.
Cidade Digital - Chapadão do Céu	Chapadão do Céu, GO	-	Local government	On January 31, the small Chapadão do Céu opened its project of Digital City. The intention is to connect all the departments, using VoIP and Internet lead to the house of the citizens. The main point of internet is on the prefecture building. From there comes out the signal to connect the departments of Health, Education, Transport and Urban Action, Social Action, and some projects such as the Division of Support for Inclusion, the Guardianship Council, the House of the Craftsman etc. A telecenter is also being implemented to take advantage of the signal.
Cidade Digital - Duas Barras	Duas Barras, RJ	-	Local government	The lack of commercial providers of Internet access was the reason for the creation of the project. Currently, Duas Barras have all its urban center with Internet, connecting all municipal departments, the Municipal Guard and the public welfare. All schools and health units located in the center are also connected and the city has a local telecenter with ten computers. The next steps of the project will be implement e-

Name of project	Location	Private Sponsors	Public Sponsors	Description
				government.
Cidade Digital - São José dos Pinhais	São José dos Pinhais, PR	-	Local government	With 978 square kilometers, São José dos Pinhais, has three times the territorial extension of the state capital, which was its biggest challenge for the installation of the Digital City project. The solution was to implement a ring Infovia that combines fiber optic technology and WiMesh. To reduce costs, has adopted a VoIP network covering 500 branches. Numbers: forty IP cameras for security monitoring, virtual libraries in eight separate districts that act as telecenters and eight totems over the city, which can be used for Internet access and consulting services.
Cidade Digital - SJRP	São José do Rio Preto, SP	-	Local government, University of Campinas	The Municipality, through the Municipal Company of Data Processing (Empro), implemented the Cidade Digital project, based on three pillars: infrastructure, electronic government and digital inclusion. There was expansion and modernization of computing machines, which grew from 600 computers (2001) for nearly 3 thousand (2008), and deployment of networks. The Empro implemented management systems in the areas of budget, purchasing, human resources, property, health and education.
Cidade Digital - Tauá	Tauá, CE	-	Local government	The call of the project is the goat-phone, public telephones equipped with VoIP technology, which enables telephone calls over the Internet, and decorated with the figure of the goat, whose creation is one of the main economic activities in the region. So far are 20, spread over 18 districts that occupy the 4,018 square km of the city. Connection and Internet in schools, digital kiosks, a local training center, a cluster of software, transparency in public squares and with free access are also on the menu of choices of the citizen of Tauá.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Cinturão Digital	State of Ceará	-	ICT company of Ceará (Etice), National Network of Research (RNP), Electrical Company of Ceará (Coelce), Hydroelectric Company of São Francisco (Chesf), and Ceará TV Station.	A network of 2,500 kilometers of fiber optic will illuminate the interior and the capital of Ceará with internet. This is the "Cintruão Digital", whose first phase was launched in March 2008. The goal is to be fully implemented by July 2009, reaching about half the territory Ceará and 83% of the population. The belt will connect digital public and state schools in the same network that can reach up to 1 Gbps of data transmission speed, in the municipalities, and 2 Gbps in the capital, Fortaleza. The project will also include the connection of last mile through WiMAX network and, where possible, transmission of electrical signals via PLC.
EMBRATEL	200 cities	-	-	Embratel is the only operator in Brazil, which already offers WiMAX services for business customers. The goal is to cover areas where no cable.
Escolas em Rede	State of Minas Gerais	Intel, MetaSys, Copasa, and Telemar	State of Minas Gerais	The project benefits all schools in Belo Horizonte, the Metropolitan Region and 172 in other municipalities, including the North, Vale do Jequitinhonha and Vale do Mucuri. 290 other schools have a satellite connection, provided by the Electronic Government.
Estradas virtuais	Celso Ramos, SC	-	Local government	In the small town, with little administrative structure, a large network of inter-schools or health posts is not priority, nor the implementation of advanced services for e-government. In fact the city, with rural areas even have phone, connect the people with the world was more important. So the option was to put the focus on providing access to the worldwide network of computers. The secretary buildings are not, therefore, connected. However, there is intend to do so in the future. Most users of the city are aged 13 to 30 years and the main use being for student and educational. The rest of the population who have not computer at home may soon use the telecenter that is in the final stage of installation.
Infovia Municipal	São Leopoldo, RS	-	Local government	The city of São Leopoldo engaged in building a Infovia for savings on telecommunications and improving public services. The project, submitted in May 2007, is divided into four stages, two already established, the ongoing third and last scheduled to be completed in early 2009. Although the City still have work ahead, the local network communications of data and voice already enjoys the authority and the population of the city.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Local Telecom	Quixadá, Ceará	Ruralfone	IFC	Based in Fortaleza - CE, but with a focus on cities in the interior of the state, the company started its activities in the city of Quixadá, Sertão-Central of Ceará in May 2005 and now forms part of the reality of the city. The company offers mobile phone services in Quixadá through GSM infrastructure supplied by Ericsson. Besides offering mobile phone services in Quixadá (Ceará), the Local Telecom is also present in three other cities in the interior of Ceará (Quixaramobim, Russian and Aracati), which have the ideal scenario for investors North American (Canada and USA) of Ruralfone, the holding company that controls Telecom Local and does business in niche markets not served by major carriers. The plan of these investors is to offer low cost telephony in low-income municipalities. These are areas that, in general, the utilities provide service for regulatory enforcement, but not usually in their strategic business models.
Monte Santo de Minas	Monte Santo de Minas, MG	-	State of Minas Gerais	The city has health units and schools connected to the city hall, Internet in the buildings outside the headquarters and telecenters for the population. Although no estimated time, is the expansion of access points to the free wireless network, which is from four to twenty, to cover 70% of the population. The goal is to bring this feature to homes of residents who pay taxes correctly.
Mossoró Cidade Digital	Mossoró, RN	Local companies	Local government, Municipal Foundation for Support of Employment and Income Generation (fungi)	The focus of the project is to promote actions of digital inclusion and stimulate projects to develop the economy and the information of the society. The project has three issues: digital inclusion, digital entrepreneurship, and finally, research and development of the city, from the demand of enterprises. The connection of the public building is also planned. The intention is to connect the buildings of the seven departments of the city, as well as 81 schools and 40 health posts. Studies on the technologies to be used will be made later.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Municípios Eficientes	State of Rio de Janeiro	-	State of Rio de Janeiro	The state government of Rio de Janeiro put in place, in 2009, the project Municípios Eficientes, which aims to provide solutions for the 92 prefectures for computerization of processes, through systems based on free software. The basic principle is that the state will only be fully effective if they are also their municipalities. The State has an interest in the municipalities to be computerize to make faster exchange of information between them. There are a number of functions of the municipalities that are too intertwined with the state functions, such as in health and education and even tax.
NAVEGAPARA	Pará State	Celpa, PadTec, and Oi	Eletronorte and Prodepa	NAVEGAPARÁ connect to high speed Internet, from five basic actions, the main administrative institutions of the state, allowing actions such as e-learning, e-business and digital inclusion. This first phase of the project was made possible by two agreements. The first, with Eletronorte, allows the State Government to use the 1,800 kilometers of fiber optic. The second was with Metrobel, which is one fiber-optic network installed in the metropolitan area of Belém and maintained by institutions of education and research. Infocentres will be built which will allow public access for two million people to the Internet, will benefit especially the productive sector, which can use it to display products and do business around the world. For the first phase of Digital Cities, the estimate is that 15 municipalities receive the Internet signal through the Infovia that is being structured: Abaetetuba, Altamira, Barcarena, Belém, Itaituba, Jacundá, Marabá, Marituba, Pacajá, Rurópolis, Santa Maria, Santarém, Tailândia, Tucuruí, Uruará.
Neovia	São Paulo	Intel, local investment firms	-	One of the Brazilian companies that may operate WiMAX services.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Paraty	Paraty, RJ	NextWave	Proderj (State ICT company)	The municipality of Paraty plead the UNESCO (United Nations Organization for Education, Science and Culture) its recognition as patrimony of humanity. For this, the UN agency requires a heavy investment in education and infrastructure, including communications. But, not to change the whole architecture, cannot install wiring or underground cables, which would require ground works and excavations in tumbled by the Institute of National Historical and Artistic Heritage (IPHAN) since 1958. The wireless technology was the solution found by the municipal administration to connect the city with its historical damage. The project was funded by NextWave as a pilot to present to market technological innovations developed within the company and already in use in several countries of the world
Parintins	Parintins, AM	Intel, Proxim, Cisco	CPqD	According to Census 2000, this year only 15.6% and 1.1% had telephone and computer, respectively. In this context, talking about wireless broadband might seem a dream. Due to the isolation of the city, the signal does not come easily. The deployment was set to work, involving heavyweights in several areas. Intel, where the idea came as part of its World Ahead Program, made the donation of equipment and personnel made available to implement. Embratel sold the satellite link for the connection to reach the city. The CPqD was responsible for planning, design, specification and installation of the Infovia Parintins and WLAN network. The Bradesco Foundation did, and still is, the distance training of professionals in the field of education. The Federal University of Amazonas (UFAM), the School of Medicine, University of São Paulo (USP) and State University of Amazonas (UEA) interact in the actions of telemedicine. The latter also works with the training of students via videoconferencing. Proxim and Cisco gave the equipment.
Paulo Afonso Digital	Paulo Afonso, BA	-	Local government	The project is the interconnection of the databases of the municipal offices, the modernization of the machinery used by public bodies and a system that includes 32 electronic solutions. Some services: obtaining duplicates of taxes, public expenditure tracking, supply of obituaries and search schedule of water-car.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Pedreira	Pedreira, SP	IgnisCom	Local government	The project began about two years, when a team of the Laboratory of Communication Networks (Larcom) of Unicamp hosted several meetings with mayors of municipalities near Campinas. The team of the university works with municipal projects infoways since 1999. The first step was to computerize the system of municipal administration. New machines were acquired and a network of optical fiber installed to connect the public buildings. Today, all employees speak among themselves for free. Municipal and state schools, which before the project had already laboratories, were connected to the Internet, as well as hospitals and health clinics in the city. Some are connected via Wi-Fi signal, others connected to the network of fiber optics.
Piraí Digital	Piraí	TAHO, Oi, Cintra, Banco Real, Itautec, and Sebrae	CNPq, BNDES, Federal Gov, Foundation of Support to Research of Rio de Janeiro, Fluminense University, Local and State government.	The project originated in an economic crisis. It was necessary to stimulate local development. The development led the city of Pirai to become one of the first digital Brazilian municipalities. Today, the 520 square kilometers of Piraí are fully covered, in spite of being a very mountainous area. All 25 institutions of teaching Piraí have access to Internet broadband. The 13 health posts also have access to broadband Internet and integrating the state hospital, and 39 public buildings.
Porto Real	Porto Real, RJ	-	Local government	The Wi-Fi technology covers 100% of the territory of the municipality with Internet. The focus is on the activities of health, industry of the municipality that is today more digitized and in which the activities of e-government is more advanced. An intranet has been developed to organize information from health posts and hospitals - are 14 units in total - stores the history of each patient and allows them to be accessed by any doctor, even those of neighboring municipalities, as required. In 2009, the intention is to migrate the technology of transmitting internet from a WiMAX network.
PRO-AMUSEP	State of Paraná	AMUSEP	SEBRAE, EMATER, State University of Maringá, Local government	The overall objective of this project is to contribute to regional sustainable development of northern Paraná. The specific objective is the establishment of an inclusive system of innovation to improve the competitiveness of micro enterprises in the region through their integration into productive chains with a greater degree of connectivity derived from the universal access to telecommunications.

Name of project	Location	Private Sponsors	Public Sponsors	Description
RuralMAX	São Paulo and remote areas	Neger Telecom	FINEP, Science & Tech	Through a network of data transmission, the RuralMax provides Internet access to remote rural properties. The RuralMAX is the service for individual residential and business applications for small companies. RuralMAX services are available initially in the state of São Paulo. For regions not yet served by RuralMAX the company recommend the services of voice and data provided by satellite, with coverage throughout the country. The telephony services are offered by the Globalstar satellite and Internet access services via satellite are provided by RuralWeb.
Saude e Alegria	Tapajós river, Suruacá, Maguari	Saude e Alegria, Ford Foundation	Petrobras, Ministry of Culture, BNDES, EU	The project Health and Happiness is a non-governmental organization non-profit making from the health triggered a series of initiatives by the integrated and sustainable community development in the region. The program promotes training of teachers for boosting education and adequacy of the local reality, workshops on environmental education and cultural rescue children from the segments, courses of education for citizenship for youth leaders, campaigns on the rights of children and adolescents, establishment of community libraries to encourage reading and support the activities of sports and leisure. With the installation of kits to community radio and publishing, dynamic participatory video, Telecenters and deployment of digital inclusion, if enable in situ production and dissemination of information, knowledge, learning resources and demonstrations of traditional culture among the communities themselves, and one for other regions.
Sorocaba	Sorocaba, SP	Microsoft	Local government	Zoo via the Internet, online tax, claims against companies via computer, register for new ventures. All that exists in Sorocaba, a city in the interior of São Paulo, which draws attention not only by making use of Information and Communication Technologies (ICTs), as well as by creativity in services offered to citizens and investors.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Sud Menucci	Sud Menucci	-	Local government	As recently as 2002, Sud Mennucci had no Internet provider, and about 30 residents were paying expensive long-distance fees to dial in. The first studies on the deployment of Sud Mennucci's Muni-Wi project started in 2002. The initial driver was the need for an Internet connection to supply municipal administrative demands in order to reduce the costs of an interurban dial-up connection. Initial studies were conducted by City Hall's IT technicians and IT managers from the local alcohol industry.
Tiradentes Digital	Tiradentes, MG	Cisco, MetaSys	Ouro Preto University, Ministry of Communications (Minicom)	The historical town was chosen by Minicom not only for tourism, and of this, naturally attract attention of the media and citizens. Rugged topography and small school network to be connected contributed to Tiradentes be elected: a place with these characteristics, various types of tests could be conducted. Thus, in March 2006, it started the installation of the project. Initially the system was installed to cover the Historical Center and part of the 83 square kilometers. This allowed the connection, in the first half of 2006, all six schools of the city (five local and one state) and single telecenter of the city. Second, coverage increased by about 30%. Thus, today there are five transmission towers: four cover the historic center of town, and the fifth antenna is located between the most populous neighborhoods of the city.
Vacária	Vacária, RS	-	Local government	In June 2008, the city of Vacaria received the award for third best in the Digital City project in Latin America in the category small municipalities. The recognition of the Asociación Iberoamericana de Centros de Investigación y Empresas de Telecomunicaciones (AHCIET), which organizes the awards, came some years after the start of the initiative, with free access to the population, the computerization of the municipal services and the connection of buildings public.
Valente Coop	Valente, BA	Sicoob-coopere	-	Valente is a town deep in Bahia in Brazil's Northeast. Here the co-op helps its members produce and market sisal, a tough fiber used in rope and in many other products, and it provides microfinance services to its members. The co-op is technologically and uses modern computerized accounting systems and has Voice over Internet Protocol phone links to it branches in 6 other nearby towns.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Vitória	Vitória, ES	Cisco, NetServices	Local government	The city of Vitória, in Espírito Santo, has since 2006 invested in the interconnection of public buildings through fiber optics and the construction of community telecenters to the population of low income to have access to new information and communication technologies. The effort is part of the modernization of government and digital inclusion.

Dominican Republic

Name of project	Location	Private Sponsors	Public Sponsors	Description
The Rural Connectivity Project	Nationwide	Codetel Claro	Indotel	The Rural Connectivity Project was launched in July 2007. At that time broadband was available in only 62 out of 383 districts and most of them were close to the five main cities in the Dominican Republic. The objective of the project was to cover with broadband all 383 districts plus 172 small communities in the 16 poorest provinces of the Country.
Centros de Capacitación en Informática (CCI)	Nationwide	Local private entrepreneurship supported also by NGOs	• Indotel • Local Institutions	Indotel started the CCI Project in order to provide access to the Internet. ICT training to the population and raise the awareness of the benefits of the Internet. The model was initially tested in Los Botados, Monte Plata, Hato Damas, San Cristobal, Salinas, Bani', Arroyo Dulce, Barahona. Today the CCI project has achieved the deployment of 834 centers. The project's technological infrastructure has been funded by FDT, while sites and maintenance are provided by institutions and members of the communities.
Estrela Telecom	Rural areas in the Southern region of the Dominican Republic	Estrela Telecom	-	Provision of telecommunications services to rural areas in the Southern region of the Dominican Republic. Delivered services are voice and broadband connectivity, with plans for offering also IPTV. A combination of wireless technology for the backbone and wired for the access is used.

Name of project	Location	Private Sponsors	Public Sponsors	Description
BecTel	Nationwide for public payphones in rural areas Los Cacaos and Bavaro for the WiMAX network	BecTel Tricom	Dominican Republic Government	BEC-TEL was awarded a contract by the Dominican government to deliver and install more than 1,700 latest generation wireless payphones in rural areas of the Dominican Republic underserved by wireless and landline phone systems. Through its telecommunications switching facilities in the United States and the Dominican Republic, Tricom provides the origination, transport and termination of local, domestic and international long distance traffic. The access network is a CDMA cellular and is owned by Tricom. BecTel is a sort of VNO. Currently, there are 1,750 public telephones in service. The customers buy calling cards from nearby "colmados" (convenience stores) and can make local or international calls from the phones. A WiMAX network was installed covering the communities of Los Cacaos and Los Botados. Delivered services are VoIP and broadband Internet (classes of services with different QoS are supported by the network). In Los Cacaos there are 10 customers for the Internet and 50 customers for voice. The situation is different in Bavaro, where there are 300 customers for the Internet and 50 for voice.
Los Botados Pilot Project	Los Botados	Viva Local entrepreneurship	Indotel	Los Botados is a rural area, with residential population and small businesses (agricultural sector). A pilot project started there with the deployment of a CCI center under the Rural Broadband Connectivity Project promoted by Indotel. Wi-Fi equipment was installed to bring connectivity to the local community (3000 people). Viva (former Centennial) is providing the service for free, although willingness to pay for the service has been tested with success (through cell phone service, two operators after the pilot project have installed base stations). The initiative is also strongly sponsored by the Local Authorities, especially by the Major Ramon Santos.

Name of project	Location	Private Sponsors	Public Sponsors	Description
Peralvillo pilot project	Peralvillo	Local private entrepreneurship	Indotel	Peralvillo is a rural village with residential population and small businesses. Jose' Alberto Hernandez runs a Wi-Fi network there. Cell radius up to 10 km has been experienced, there's the need of improvements to the backhaul connectivity. He contracted VSAT connectivity from two different companies, but there are currently following issues with satellite connectivity: high cost, quality of the connection (due to delays, influence of the weather).
Yautia pilot project	Yautia	Local private entrepreneurship	Indotel	Yautia is a rural village close to Los Botados with a residential population of 50 families living of agriculture. Two young boys who had seen the pilot project in Los Botados , started the initiative almost one year ago by building an antenna on the top of a coconut tree to capture the Los Botados signal, but it was very weak. On June 16, 2008, with Indotel support, they inaugurated a community hotspot that covers all of it and also a 5 computer training center in the local school promoted by Indotel through the CCI project. They get the Internet signal from Los Botados by a radio link.

Guatemala

Name of project	Location	Private Sponsors	Public Sponsors	Description
Planeta en Linea	Tecpan, in the department of Chimaltenango, ongoing the extension of the service to Guatemala City	Oportunet (commercial name of the NGO Oportunet) Received support from USAID	-	As the Franchise organization, PEL, contracted out most of the telecommunications infrastructure management to UNITEL, a local operator experienced in WiMAX deployments. Unitel also had the 3.5GHz frequency license. Although the regulatory environment is open, this decision was driven in part because of the natural monopolies often created through the current frequency-licensing scheme (see section on Regulatory Environment). The network has about 130 users both residential institutional (schools, court, government office). 90% of users have subscribed for the 64kbps plan priced at GTQ99 (US$12.50) Some services available, but not yet brought online include: • Pre-paid (pay as you go) Internet service • On-demand speed increases • VoIP Telephony with local number
Guateconnect Project	Nationwide	FunSepa (NGO)	Guatemala Government	FunSEPA 's mission is nation's development by using technology as a tool to advance the educational level of the population. FunSEPA is currently committed in two projects Tecnologia para Educar and Abriendo Futuro. The **Guateconnect** project has the objective to bring free nationwide connectivity to each school, teacher and student at home.

Peru

Name of project	Location	Private Sponsors	Public Sponsors	Description
BAS Project	Nationwide	Telefonica	FITEL OSIPTEL Ministry of Transport and Communications	FITEL has designed a project called "Provision of voice and data services through broadband for rural localities in Peru - broadband in isolated localities" ("Provisión del Servicio de Datos y Voz en Banda Ancha para Localidades Rurales del Perú - Banda Ancha para Localidades Aisladas - BAS", BAS). The Project, developed by FITEL, will benefit more than one million 658 thousand habitants in 3,852 remote rural locations nationwide: 3,010 with public phones, 497 locations with fixed telephony, and 1,019 with Internet access. The Ministry of Communications (MTC) will supervise the implementation and management of the Project with FITEL and OPSITEL.
BAR Project	Nationwide	Valtron Rural Telecom	FITEL	The BAR project has the objective to deploy broadband Internet via wireless and public phones in 3010 rural communities. The BAR project will provide following services: • Public telephony in 1535 communities still lacking the basic service • Residential telephony in 95 communities • Access to the Internet through the deployment of 2840 telecenters with bit rates in the range 600 Kbps - 256 Kbps Two companies have been awarded the Rural Internet project: Valtron and Rural Telecom. Valtron will bring voice and broadband Internet to 1050 communities spread all over Peru by deploying a CDMA 450 network. Rural Telecom was assigned the BAR project for the following areas: Central Peru (Departmens of Huánuco, Lima, Junín, Pasco y Ucayali), Central North (Departments of Amazonas, Ancash, La Libertad, Loreto y San Martín), impacts on 316,608 inhabitants in 542 communities, North East (Department of Cajamarca) impacts on

Name of project	Location	Private Sponsors	Public Sponsors	Description
				348,659 inhabitants in 653 communities.
Rural Broadband for the towns of Juliaca-San Gabán - Puerto Maldonado	Madre de Dios Region	Still in the bidding Process	FITEL	The project focuses on the high voltage line which is planned to be built between the cities of Puerto Maldonado San Gabán, and Juliaca at a cost of approximately $ 10 million and that will provide good quality hydroelectric power to San Gaban populations that live in the adjacencies of the inter-oceanic road in the section from Puerto Maldonado to San Gabán through major towns of Masuko and Laberinto. <u>Project Objectives are:</u> • Improving the infrastructure, efficiency and quality of telecommunications services in the towns of the province Tambopata and Manu in the region of Madre de Dios • Contribute to reducing the digital divide in Madre de Dios region through the provision of fixed telephony, public telephony, broadband Internet access to 89 locations in the province of Tambopata and Manu. The project will cover the whole region. Following services will be provided: -Internet to 36locations. -Fixed Lines to 14 locations. -Public Phones to 76 locations
Telco Services for the Rural Areas Buenos Aires - Canchaque, Piura Region	Buenos Aires - Canchaque, Piura Region	Still in the bidding Process	FITEL	The Transportation Law Nº 024-2007-MTC from the Peru Government enforces the deployment of fiber optic along the new roads. The construction of a new 70 km road connecting Buenos Aires and Canchaque to Hunacabamba will thus bring the additional benefit of extending the backbone connectivity. The electrical Company ELECTRONOROESTE S.A. will provide the infrastructure. <u>Project objectives are:</u> • Improving the infrastructure, efficiency and quality of

Name of project	Location	Private Sponsors	Public Sponsors	Description
				telecommunications • Contribute to reducing the digital divide through the provision of fixed telephony, public telephony, Internet and broadband access <u>Services</u> -Internet connectivity to 249 communities. -Fixed Lines to 201 communities. -Public Phones to 536 rural areas.
Econocable	Madre de Dios Region	Econocable and other private investors	-	Econocable started its commercial service as a TV operator in 1996. Econocable provides the service to following cities: Iquitos, Mollobamba, Tarapoto, Puerto Maldonando, Chimbote, Lima – Villa el Salvador, Quillabamba, Barranca, Paramonga, Pativilca. Six years ago, Econocable started to serve the Madre de Dios region which is the poorest area in Peru and the less populated region. There are 8000 households and Econocable serves 1000 households paying 45 soles/month. Econocable provides the Internet service via satellite to 50 users in the Madre de Dios region but the capacity is very limited. The Company has plans for extending the triple play offer in the Puerto Maldonado area through a combination of wireless for the last mile access and fiber optic for the backbone.

Name of project	Location	Private Sponsors	Public Sponsors	Description
The Televias Puyhuian Project in Jauja	Jauja, a province in the department of Junin located just East of Lima	Televias Puyhuan	-	Sponsored by USAID, the objective of the project was the identification of a viable business model for a microtelco providing internet access to an area affected by a market efficiency gap due to poverty and geographic isolation, the development of the community, and the assessment of the willingness of the community to pay for the services. The commercial service was launched in April 2006. Fixed telephony and Internet service are delivered with following pricing for residential users: • Voice: US$ 15/month with 18 minutes free • Internet: US$ 10/month per family Institutions connected to the network include: municipalities, health facilities, schools and a security network.
The Huaral Valley Project	Huaral Valley, Peru's Pacific Coast, 90 kilometers north of Lima	CEPES (NGO) and Irrigation Board	Ministry of Agriculture FITEL	The project was sponsored and developed by NGO CEPES with the Irrigation Board. It involved the installation of telecenters in rural communities and the creation of a web-based information system for water management and cultivation monitoring. The agrarian information based on wireless technology to interconnect several points in the valley, had following objectives: contribute to ICT appropriation by farmers and the rest of the population; improve the administration of the Irrigation Board and provide farmers with access to useful and appropriate information. It was also determined that the system should be financed by selling telecommunication services. A Wi-Fi network was deployed joining twelve villages in the valley and connecting them to the Internet through a shared 512 kbps link Interconnection between the 12 Huaral Valley irrigation commission information centers. The system supports an information system (YACU) for water resource management and cultivation monitoring. Recently Nokia Smart Phones have been distributed in the area of the Huaral Project, to allow users to enter data about the water management as opposed to having to go to the telecenters to enter this data.

Name of project	Location	Private Sponsors	Public Sponsors	Description
The Cajamarca Connectivity Project		ITDG (NGO)	FITEL	The Cajamarca connectivity project which had three main components: deployment of telecenters, development of rural telephony, and implementation of an information system relevant for the small rural farmers in terms of productivity. The telecenter component was not financially sustainable and today just one telecenter in the area is still in operation. Lack of support from the Municipality is recognized as the main reason for the failure of the project.
The Televias Huarochiri Project	Callahuanca District	Valtron	FITEL	A wireless network built using the CDMA 450 technology which provides both mobile and fixed access in the 450 MHz frequency band for rural, suburban and sparsely populated areas. Provided services are telephony and Internet access. The network has now almost 300 subscribers, the traffic is higher than estimates and the project is succeeding. Valtron has 50 employees hired from local population, most of them are technical personnel and engineers.

Name of project	Location	Private Sponsors	Public Sponsors	Description
The Puyhuan Project	Jauja	Puyhuan (NGO)	-	Puyhuan would like to replicate the USAID project in a larger areas of Jauja, which consists of 34 districts with a population of 120,000 people. Fermin Torrejon a local entrepreneur, is focused on an interdisciplinary approach to economic development in Juaja that leverages broadband networks to deliver the following applications to the community: • Distance learning • Remote medical consultations • Online medical records including medical history • Online scheduling of medical appointments • Online medical inventory management Puyhuan currently has developed a project to develop a Digital Valley in Juaja that would involve the interdisciplinary approach described above to integrate the deployment of a broadband network to promote community and economic development.

ANNEX 4 – METHODOLOGY

Tech4Dev, in association with Excelsio Communications, has been hired by the Inter-American Development Bank to carry out a study on Economic Development and Inclusion through Local Broadband Access Networks. Our work started at the beginning of August 2008 and was completed by end March 2009. The theme of the study is the recent experience of community-based initiatives – driven by municipal governments, community organizations, local entrepreneurs associations, NGOs – that have deployed sustainable local broadband connectivity services.

Multiple approaches were used to generate the information presented in this report. To offer a realistic view of the existing best practices and identify key success factors for the implementation of sustainable local broadband access networks, we followed a four step process:

1. Desk review
2. Phone interviews with stakeholders
3. Mapping of existing best practices
4. Country visits to Brazil, Dominican Republic, Guatemala and Peru

This process was designed to produce insights going beyond publically available information and identify all key issues involved in the deployment of local access networks. In addition, the process allowed us to prepare a long list of potential opportunities which could be the focus of the development of three network concept projects for MIF.

The objectives of the desk review, our first step, were as follows:

- explore challenges and solutions in five key areas for network feasibility: (i) network technology, (ii) business models, (iii) value added services, (iv) funding and financing, and (v) regulation and legislative policies.
- provide an analysis of worldwide best practices in the deployment of sustainable local broadband access networks; and
- draw some initial lessons from experience.

A cross selection of relevant studies and business cases was analyzed with particular attention paid to access models that are suitable for urban, remote rural and non-remote rural environments. An initial mapping of best practices, based exclusively on the desk review, was prepared.

For the second step, the team conducted fifteen phone interviews with local experts, public officials, and business stakeholders, to gather additional insights on service requirements, understand barriers, test reactions to potential solutions and models, and explore attitudes toward existing service needs and available solutions.

The third step consisted in the update of the detailed mapping of best practices identified through the desk review based on the information from stakeholders. This effort combined with the team's knowledge of

network models and their performance, led to the identification and preliminary analysis of network architectures, business and financing practices that can be localized and adapted to local conditions.

For each key area of network feasibility and strategic choices (i.e., technology, business model, financing, services), we characterize the basic issues, analyze existing best practices and how recent innovations and new models may affect network roll out and sustainability, especially where traditional approaches failed.

A substantial amount of information on which this report is based was gathered during the field visits carried out as part of the fourth step of the study. During these visits, the team worked sequentially on the assessment of the enabling environment at national and local level and on the identification and development of country specific local access network projects. There were in fact two separate one-week visits (one on the enabling environment and the second on project identification) during which meetings were held with the senior staff of Regulator, Universal Service Funds and Ministry of Transport and Communications, major private sector players, Universities, Research Institutions and NGOs. Further activities have comprised field engineering visits to installations and network initiatives in order to evaluate the configurations of existing broadband systems and assess the economic activity in the surrounding areas.

Finally, as an output of the desk review and sharing of lessons learnt during the four field visits, we provide here a series of recommendations on implementation of sustainable local broadband access networks. Although these recommendations were made in the context of Brazil, Dominican Republic, Guatemala, and Peru, they may be applicable to other locations, as most are built on best practice.

ANNEX 5 – INTERVIEWEES

Brazil

Geanderson - State Government - *Technical Coordinator*

Magda Marostegan - State Government - *Secretary of Education*

Dr. João Crisóstomo - Secretary of Science and Technology of Pará

Lamartine Souza - Prodepa - *Technical Advisor of the Presidency*

Dr. Leonardo Mendes - *Titular Professor from University of Campinas and director from IgnisCom*

Juliano Castilho Dall Antonia - CPqD - Center for Research and Development in Telecommunications -*Director of services*

Fernando Arruda - Venturus - *CEO*

Elisabete Trachez do Couto – EMBRATEL

Agostinho Linhares - ANATEL – *Band Allocation Manager*

Marco Tavares – ANATEL – *Operational Manager*

Denis Côté - Local Telecom - *CEO*

Ranúsio Cunha - Cooperativa Valentense de Crédito Rural

Átila Augusto Souto – Director of Universal Service - Ministry of Communications

Lila Ganzer - Coordinator of the working group on FUST – ANATEL

Amilton Lamas - CPqD (Center for Research and Development in Telecommunications)

Fabrício Lira Figueiredo - CpqD

Silvio Rogatto – WxBR

Antônio Neger – Neger

Elisa Peixoto - President's Office - *Advisor of Digital Inclusion*

Dominican Republic

Edwin San Roman - Indotel - *Consultant*

Neil Checo Valera – FDT *Manager*

Jose' Alberto Dominguez V. - FDT - *Senior Engineer*

Jose' Alfredo Rizek V. -Indotel - *Member of Indotel's Board of Directors, Advisor to the President and former Indotel Excutive Director*

Ahmed Awad - Codetel Claro - *Director Proyecto Banda Ancha Rural*

Silverio Dos Santos - Estrela Telecom - *President*

Edison Rodrigue- Bectel - *Sales Director*

Radhames Guillermo Banca Corporativa - Banco BHD - *Vice President*

Joelle M. Exarhakos C. -Indotel - *Executive Director*

Manuel E. Bonilla - Wind Telecom- *Executive President*

Fausto Alvarado -Orange - *Strategic Planning Man*ager

Ing. Claudio M. Pegero Castillo General - National Police - *Technology Advisor to the National Police Chief*

Claudia Garcia - Viva - *Vice President Legal and Regulation*

Victor Reynoso - Ademi Bank - *Manager Main Branch*

Guatemala

Arturo Muente Kunigami - World Bank

Maria Mercedez Zaghi - ErgoCOM.Net – *Operations Director*

Ben Sywulka - Planeta en Línea – *Executive Director*

Regina Sandoval - FunSEPA- *Executive Director*

Roger Torres FONDETEL -*Manager*

Enlace Quiche

Ing. Jorge J. Ruiz - Chamber of Commerce of Guatemala

Lic. Jose' Bernardo Pineda Jurado - Chamber of Commerce of Guatemala *Director*

Rick Garland, USAid Director Oficina de Empresa, Comercio y Ambiente

Lic. Luis Arnulfo Elias Higueros – FONDETEL- *Manager*

Fernando Herrera - Agexport - *Director*

Roger Torres – FONDETEL -*Manager*

Rodrigo Robles – SIT - *Manager*

Peru

Cecilia Fernandez - Engineers Without Frontiers

Carlos Alberto Sotelo Lopez - FITEL- *Technical Coordinator*

Oscar Bravo Burga - Voxiva - *Business Development Manager*

Henry Okumura Suzuki - Econocable -*Operations Manager*

Daniel Segovia Sachez- Econocable - *General Manager*

Aldo Schenone Dulanto – ProInversion - *Director of Telecommunications Projects*

Ruddy Valdivia - Valtron - *Executive Director*

Carlos Sanchez Tarnawiecki -OSIPTEL - *Manager*

Rolando Pacheco - ITDG- *Manager*

Jorge Bossio Montes de Oca – OSIPTEL- *International Relations Manager*

Sofia Pique Cebrecos - COMEXPeru - *Economic Studies Analyst*

Rafael Zacnich Nonalaya - COMEXPeru - *Analyst*

Maicu Alvarado – CEPES - *Manager*

Cesar Campos Rodriguez- DETEC - *Executive Director*

Roxana Barrantes – Instituto de Estudios Peruanos (IEP) - *Economist*

Julius San Roman – SIA Project

Peter Wolf – Rural Telecom - *Integrated Programs Expert*

Carlos E. Ramirez Valdivieso – Rural Telecom - *Director*

Rolando Toledo Vega - RCP - *General Manager*

Vicente Ricardo Arnaiz Muñoz - Telefonica del Peru

Seneca de la Puente Estremadoyro - Telefonica del Peru – *Vice President of Network Operations*

Fermin Torejon Salazar - Entrepreneur

ANNEX 6 – BIBLIOGRAPHY

Ahson, Syed and Ilyas, Mohammad - *WiMAX Applications* , CRC Press September 2007

Bossio, Juan Fernando - *From an Information System and Telecenter Network Project to a Community Network: Building Financial Sustainability through Social Sustainability*, Lirne, December 2007

Cisco Internet Business Solutions Group (IBSG) - *Brazil Extends Broadband Technology to Tiny Municipality to Promote Benefits of a Digital City, 2007*

Corinna Aichele, Rob Flickenger, Carlo Fonda, Jim Forster, Ian Howard, Tomas Krag, Marco Zennaro - *Wireless Networking in the Developing World*, January 2006, Limehouse Book Sprint Team

Galperin, Hernan and Bar, François, 2006 - *The Microtelco Opportunity: Evidence from Latin America* Galperin, Hernan and Girard, Bruce, 2005 - *Microtelcos in Latin America and the Caribbean*

Galperin, Hernan and Mariscal, Judith, 2007 - *Digital Poverty: Latin America and Caribbean Perspectives*, REDIS, DIRSI

Galperin, Hernan - *Wireless Network and Rural Development*, Research Report, 2005 The Massachusetts Institute of Technology Information Technologies and International Development Volume 2, Number 3, Spring 2005, 47–56

Ganz, A. ; Ganz, Z. and Wongthavarawat, K. - *Multimedia Wireless Networks*, Imprint Upper Saddle River, NJ: Prentice Hall PTR, 2004.

Instituto de Estudios Peruanos and Annenberg School for Communication at the University of Southern California - *USAid Last Mile Initiative in Peru*, January 2006

Intel, 2008 - *Building a Digital Village – Best Practices and Getting Started Guide*

Intel, 2007 *Cost-effective Rural Broadband: A Vietnam Case Study*

International Telecommunication Union (ITU). *Case Study – Bolivia,* March 2007

Malcolm Matson and Rod Mitchell, March 2006, *Study On Local Open Access Networks For Communities and Municipalities* InfoDev

Matiæ, D. - *Introduction to OFDM, II Edition, OFDM as a Possible Modulation Technique for Multimedia Applications in the Range of mm Waves,* http://www.ubicom.tudelft.nl/MMC/Docs/introOFDM.pdf, 1998.

Nair, G.; Chou, G.; Madejski, T. ; Perycz, K. ; Putzolu, D. and Sydir, J. - *IEEE802.16 medium access control and service provisioning*, Intel Technology Journal,Vol. 8, No. 3, 2004.

Network for Inclusive Markets, 2008 - *Unmet Needs and Business Solutions for the Majority in Latin America*, Report to the Inter American Development Bank

Owen, Darrell - *Applying 21st Century ICT in Emerging Markets,* September 2008

Owen, Darrell - *Expanding Rural Access*, Associated Working Papers, January 2008

Owen, Darrell - *ICT4Development: Achieving Sustainable Community Networks*, June 2008

Porteous, David with Neville Wishart, 2006 - *m-Banking: A Knowledge Map*, Washington DC, InfoDev/World Bank.

Regulatel - *Guatemala Last Mile Initiative Tecpan: Small community Based Micro Operator*, November 2006

San Roman, Edwin - *Microtelcos and Regulatory Issues*, November 2007, Research supported by IDRC for Dominican Institute of Telecommunications (INDOTEL)

Siochrù, S.O. and Girard, Bruce **-** *Community Based Networks and Innovative Technologies: New Models to Serve and empower the Poor,* UNDP 2005

Souter, David *Equitable Access People, networks and capabilities*, APC 2007

Stern, Peter A. and Townsend, David N. - *New models for Universal Access to Telecommunications Services in Latin America*, Regulatel, November 2006

Tan, Liang - *Case Study – Bolivia*, ITU March 2007

Wong, Wilye - *Discovering the Wonders of WiMAX*, TechForward August 2007

Multilateral Investment Fund (MIF)
Inter-American Development Bank
1300 New York Avenue, N.W.
Washington, D.C. 20577
www.iadb.org/mif