Affordable Wireless Connectivity Linking Poor Latin American Communities Binding Their Schools by Sharing ICT Training for "Maestros" of Primary Schools

C. Osvaldo Rodriguez

INIFTA, Universidad Nacional de La Plata,
Diagonal 113 y 64,
La Plata 1900, Argentina
cor_ar@yahoo.com

Abstract. A very poor neighborhood in Argentina that has many features of lower middle class is called "barrio carenciado". Many heads of the families are unemployed and although children have access to schools it is common that they do not finish their basic instruction. In many cases NGOs play a fundamental role in changing this reality. In this presentation we detail the implementation of a test bed where 14 families and a school were provided with computers, Internet access and were educated out of digital illiteracy. Connectivity was provided by Wireless Mesh Networking (WMN). The research project, was carried out by a group of researchers from the Universidad de La Plata with different backgrounds in collaboration with the NGO Barrios del Plata (a chapter of Muhammad Yunus´s Grameen Bank). The study monitored the changes in families' life (in particularly children education and parents opportunities related to obtaining work). The deployment of WMN in a such a broad area, aimed to define the possible lowest cost implementation, and conforms an important part of the research activities. The school #502, originally a node of the WMN, has become a "Laboratory for the use of innovative methodologies in ICT training of primary school teachers". The project was financed through an award given in a public competition by Microsoft research and CentralTech, a leading Argentinean educational center.

Keywords: Digital Inclusion, Wireless Mesh Networking, ICT Teachers Education.

1 Introduction

If true what Thomas Friedman states in his best seller "The World is Flat" [1], then underdeveloped countries have a great opportunity, meaning, an opportunity for the promotion of new businesses and changes in areas such as education, R&D, health and many others.

The facts that Friedman stated made the world to become flat go from Ethernet's invention, the Personal Computer, Internet, the dot com bubble (that filled the earth with optical fiber), Netscape, XML, SOAP (which gives the possibility of connecting very varied applications), free access to information (search engines such as Google,

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Yahoo and MSN) to the most recent advances such as mobiles, wireless, virtualization and quadruple-play. It was the sum of these factors which happened in conjunction with some very particular political events.

In resume, a more planar world has been generated, where information is a click away. Some underdeveloped countries are somehow better prepared than others after the technological changes of the last years. And these countries could obtain immediate benefits from the use of ICTs. They have acquired the necessary physical infrastructure (as optical fiber) and possess the human capital required to operate the associated systems. Its use cannot bring any other consequence than economical growth and improved standards of living.

When PCs still did not interconnect, the challenge to break the "digital divide" was enormous for underdeveloped economies. The panorama was dull since those societies with access to computers and the applications running on top of them would become more and more apart from those that needed first to come out of digital illiteracy to just then start benefiting from the so called "Information Society".

"Those rich in information would become richer and those in need would be still poorer". With this phrase, Nicholas Negroponte expressed in his article "One-Room Rural Schools" which appeared in Wired Magazine (of which he was founder), in September 1998, his concern for the increasing separation of those who had access to computers and those who didn't.

But access to internet and the many ingredients that made the earth flat modified this situation, transforming a problem into a challenge. The same tools of IT and advances in telecommunication (today nearly convergent) gave the tools to solve the problem.

There is no doubt that the opportunity is there, the important issue is to know how to take advantage of it. Some countries like India are already immersed in big changes. In Africa the problem is still more complex since huge investments in physical infrastructure are needed. Many Latin-American countries that have the necessary physical infrastructure are still "deciding" what to do.

But, the fact that the earth is flat, the free access to libraries and their content offered by Internet, thousands of developers willing to help in open-source projects, the multiplicative effects for education and many other areas makes it possible to perform a radical change in poor countries. Simple: start tackling problems.

From our perspective two of the most urgent and key actions are: Internet connectivity and enhancing teacher's digital literacy.

2 ICT4D-AR, UNLP

ICT4D-AR is a project that gathers researchers from different backgrounds, mostly from the Universidad Nacional de La Plata and that belong to the most prestigious research institutions in Argentina: CONICET and CIC. Its main objective is to investigate the design and implementation of new technologies that favour underdeveloped regions.

The purpose of ICT4D-AR is to focus on the challenges posed by the ICT revolution to those that live in countries where great parts of their population are below the poverty line. The great majority of this type of projects use technologies developed in

countries with intellectual, economical and educational wealth. The sheer implementation of many of them simply fails since no questioning is made on costs, feasibility of implementation, energy problems or the need to orchestrate the appropriate educational support and study these technologies within the local eco-systems. What's the value of giving away laptops to primary school children if their teachers never used a word processor nor sent an e-mail?

ICT4D-AR tackles problems related to hardware, software, connectivity and its influence in education and work opportunities. The project, finally, pretends to give a diagnosis, promote the proper technologies that eventually might be adopted by governments and corporations.

Today ICT4D-AR is focused on two projects: wireless connectivity using WMN and innovative methodologies for ICT training of primary school teachers. The project's participants come from different backgrounds and include technologists, scientists from the hard sciences, engineering and social areas. One of the pre requisites of any new project is that it should be carried out in real environments (pilot tests, testbeds). This is vital, since it provides the answer to its feasibility and gives a diagnosis for scalability.

3 Project Wireless Mesh Networking (WMN)

In 2004 Tom Krag and Sebastian Buettrich [3] proposed, during the Emerging Technology Conference organized by Tim O´Reilly that took place in San Diego, CA., how WMN could become an important technology for the promotion of wireless and internet access in underdeveloped regions. They addressed the question of how one could give access to internet and connectivity to those places not included in the commercial plans of telecom companies or if the connectivity was there, how it could be provided at a low cost.

One of their main arguments in their analysis was the need to have a decentralized connectivity infrastructure. In this manner one avoided a single point of failure. Another, that the technology would be sufficiently simple and low cost so that it could be maintained and expanded by local participants with very little technological experience.

It basically proposed the use of low cost hardware, home constructed antennas and ubiquitous technologies simple to implement. Wi-fi (802.11b/g) prompted as a candidate technology and connectivity in mesh architecture a promising ingredient.

In the last years the group of Dr. Victor Bahl, from Microsoft Research implemented mesh technology as part of Windows XP [4]. Krag´s and Buettrich´s proposal made us interested in the idea. In 2006 the project won a RFP made by Microsoft Research for the implementation of the test bed described in this paper using the technologies developed by Dr. Bahl´s group.

3.1 Definition of Mesh Networking

"A mesh network is a network that employs one of two connection arrangements, full mesh topology or partial mesh topology. In the full mesh topology, each node is connected directly to each of the others. In the partial mesh topology, nodes are connected to only some, not all, of the other nodes" [3].

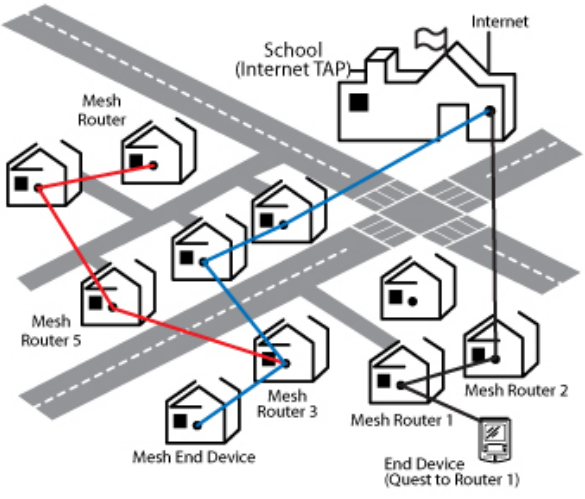

Fig. 1. Diagram of "Barrio Carenciado" and Mesh Nodes

When we speak of mesh networking, we understand a network that has connections many to many and capable of dynamically updating an optimizing these connections. The nodes can be mobile or not. In our case they are not mobile since their position as a function of time does not change. Fig. 1. shows a diagram of a possible mesh implementation. The biggest challenge for any mesh configuration is the administration of the complex information from the routing tables since they must include external networks and the internet gateways.

Mesh network technologies have matured and have found a place together to other possible wireless technologies. Some of the outstanding issues, adapted to our scenario, as pointed by Krag and Buettrich [3], are:

- **Price:** 802.11 radios have become relatively inexpensive, although they are still among the most expensive elements of such a network. It's the fact that each mesh node runs both as a client and as a repeater, which permits saving on the number of radios needed and thus the total cost.
- **Ease and simplicity:** In our case each node is a PC running Windows XP with wireless mesh software and uses standard wireless protocols such as 802.11b/g and the setup is extremely simple.
- **Organization and business models:** The decentralized nature of mesh networks.
- **Network robustness:** Mesh topology and ad-hoc routing should provide more stability in the face of changing conditions or failure at single nodes.
- Today a mesh infrastructure can be built with hardware from CISCO or Motorola but they are very expensive. The challenge is a low cost implementation.

4 Barrio Carenciado, NGO "Barrios del Plata" and Testbed

The WMN project started in September 2006 and ended in december 2007. The test bed linked 14 homes (with children in primary school age and unemployed parents)

Fig. 2. El Obrador

and had its gateway to the Internet in a local community meeting place ("El Obrador, Fig. 2.). Another selected node was the primary "Special School #502" for children with learning disabilities. Each of the families used Internet for different purposes but, the study concentrated on educational issues of primary school children and if it could provide possible means for reverting the parent's situation of unemployment.

The idea of Grameen Bank started by Muhammad Yunus, has helped improve millions of peoples life worldwide. In Argentina Grameen Bank exists since 1999 as "Aldeas Argentinas". Our project rested on the NGO as the way for selecting the families that received the computers, give them support in education and guiding the participants as a community. "El Obrador", normally the meeting place of the ONG, was practically converted in a training centre. For months the families received courses and several very interesting experiences and positive returns emerged.

The project put up the whole infrastructure, serviced the antennas and connectivity and provided funds for IT education.

5 WMN: Reality versus Laboratory

In 2004 in the Freifunk Summer Convention in Berlin, Krag and Buettrich [3], demonstrated the feasibility of a mesh network using a few laptops connected using the protocol Mobile Mesh on top of the GNU/Linux kernel 2.2 in the streets of Berlin surrounding a park.

Could it be possible to implement this at a very low cost in a real environment and not as an experimental laboratory? This was basically the question that made us implement the project.

Our 15 nodes were distributed as shown in Fig. 3.: two groups of 5-6 nodes and 4 nodes at the border.

In parallel to the study of connectivity and as already stated each family assisted to training in basic informatics tools (Word, Excel, PowerPoint). All the training was done in the node called “El Obrador” that also served as the gateway for Internet using an ADSL connection of 512Kbps.

Two advanced engineering students from the Facultad de Telecommunications of the UNLP made the appropriate deployment. They had special contracts through university fellowships, a legal figure called “pasantes”. They were in charge of deployment and monitoring of the network.

Each node consisted of a PC running windows XP, a wireless network card 802.11g and an external antenna 5m high placed on the roofs of the precarious housing of each family. In the implementation we made use of the “Mesh Networking Academic Resource Toolkit 2005” offered by Microsoft Research. The protocol used is called Link Quality Source Routing (LQSR) based on Dynamic Source Routing. The MCL (Mesh Connectivity Layer) driver was installed in each wireless card. Linksys WMP54G cards were used on each node, connected to an 8Bdi antenna. A coaxial RG8 cable of little loss was used for connecting the antenna and the PC. The antenna was held together with the TV antenna of each home. Although not optimal due to losses in the cable, this solution was decided due to cost. Use of a bi-directional amplifier or LNA would have increased total cost. It was always in the spirit of the project a search for lowest cost implementation. Although commercial antennas were used, the final aim was to replace them by home made ones.

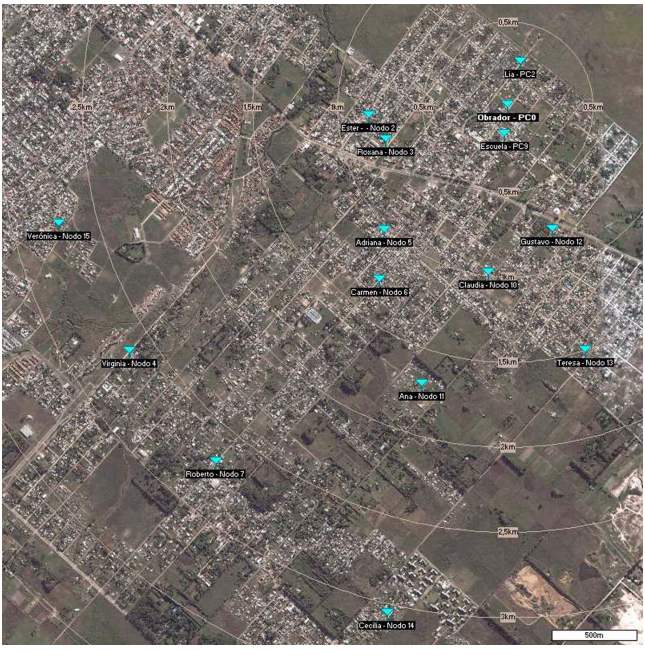

Fig. 3. Map of Villa Elvira and Nodes

5.2 Implementation #1

The first implementation was a full mesh topology where all the nodes participated meshing and a single gateway was located at the node called “El Obrador”. Omini directional antennas of 8Dbi were installed at a cost of U$50 each.

Connectivity was achieved between all 15 nodes but several factors attempted against the stability of the network. The Mesh protocol was installed in “zero configuration”. This brought many problems. If a node needed to be reset, it would modify some parameters and technical personal needed to be called to reconfigure.

Given the small number of nodes, the disappearance of one of them would leave several others without connectivity. Zero configuration was finally eliminated in the installation scripts. This made that many of the problems described when resetting disappear.

5.2 Implementation #2

As a possible solution to the instability observed in implementation #1 the antennas of some nodes were changed for directional ones of 24 dBi. This hybrid model then had mesh in the two more dense areas and the rest in infrastructure mode and provided a much more stable network.

6 Project Escuela # 502: ICT Training for Teachers

The “Laboratory for the use of innovative methodologies in ICT training of primary school teachers” was implemented in the Escuela Especial #502 (see Fig. 4.), Villa Elvira, La Plata at the end of the WMN project. The school, caters for children with learning disabilities is a public school and belongs to the Provincia de Buenos Aires. The laboratory´s formal inauguration was November 2007 although already many actions had been made as pilot tests using a reduced infrastructure.

Fig. 4. Front image of Escuela#502

The neighbourhood, the school's infrastructure and the children´s families are poor.

Within the project researchers and university professors from the Universidad Nacional de La Plata, CONICET and CIC were in charge for the training of primary school teachers. The theoretical propositions made for the Masters Degree projects in Tecnologias Educativas are used the laboratory as a test bed. As examples we mention work carried out with professors from the School of Music of Facultad de Bellas artes from the UNLP and the use of classmate PCs in the classroom with children with learning disabilities.

The teachers find an environment of great academic level for their training immersed in original and creative projects. This is later reflected in the projects proposed by the teachers to carry out with their students.

The year 2008 was fundamentally used for training for those that teach in the school and will continue expanding to teachers from other establishments. Several teachers have already been detected with great interest in the project and will become trainers in future cycles. Part of the projects objective is this multiplicative factor.

The coordination is made by the Instituto de Investigación en Informática (LIDI), Facultad de Informática, UNLP together with the Cátedra de Postgrado de la UNLP one Tecnologías educativas (http://www.info.unlp.edu.ar/externas/postgrado/).

7 Results and Conclusions

The WMN project was carried out by a multidisciplinary research group from the Universidad Nacional de La Plata in conjunction with the NGO Barrios del Plata. Funding was provided until December 2007. Conclusions related to this project are detailed below:

- The implementation of the wireless mesh was far more complicated than originally assumed. Laboratory test beds are described in the literature but many complications as antennas, selection of wireless NICs, and other details made the deployment far more difficult.
- Dealing with the paperwork due to regulations from CNC (Comision Nacional de Comunicaciones) for sharing an Internet connection through a broad area was also a hurdle that took energy and was originally not foreseen as a problem.
- One main conclusion after the experience is the importance of having an NGO involved. They have been many years in the neighbourhood, know the families and are there for the daily issues. A Test bed deployment without such a support would surely end in failure.
- One family that received a computer with access to Internet was selected independently from the NGO. The idea was to monitor changes in their life as compared to the rest. They, of course were free to pursue actions without constrains. The mother of the family found a small mosaic factory that offered her part-time work using her computer in processing daily excel editing.
- The "Special School #502" was originally incorporated as a node that provided Internet to the establishment. A few months later, a teaching/research laboratory was planned. Some pilot educational projects were carried out and at present a complete learning laboratory has been implemented.

- After the end of our involvement, the mesh could not be maintained and the shared connection at the "Obrador" discontinued.
- Four families have established a small enterprise based on the computer and internet connection. Other four use it as a tool for their small businesses. They are mostly run by the woman in the house.
- All families except one, keep their CPUs working. Most use free dial-up connectivity to internet and 60% bought a printer. All of the children use the computers for school work. The only case where the CPU is not active was due to a falling of a ceiling.
- Although the costs of sharing an internet connexion are far less per household, keeping an infrastructure like WMN is complex. The scale of our project was most probably too small.

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