Implementation of a Long Distance Radio Link using Low-Costhardware

Juan Ochoa Aldeán, José Cuenca Granda, Byron Solórzano Castillo, Julio Romero Sigcho

Abstract.-The long distance links with low-cost hardware have been used to interconnect rural populations in places where incumbents fail, and it is a global initiative for developing countries. This initiative has been promoted by various agenciesas: TIER, ICTP, ESLARED Foundation. This article describes the implementation of a radio link between the Villonaco Hill and the National University of Loja, using the experience gained by various agencies in the development of WiFi-based Long Distancetechniques. WiLD network with links as long as 50-100 km have the potencial to provide connectivity at substantially lower costs than traditional approaches. However, real-world deployments of such networks yield very poor end-to-end performance. First, the current 802.11 MAC protocol has fundamental shortcomings when used over long distances. Second, WiLD networks can exhibit high and variable loss characteristics, thereby severely limiting end-to-end throughput. In the implementation was used thewell-known Linksys WRT54G routers, where the factory firmware was replacedfor DD-WRT firmware. We also present the feasibility of the radio link through Radio Mobile Software, and the results using the PING command.

Keywords: WiLD, IEEE 802.11, DD-WRT, Radio Mobile.

I. INTRODUCTION

At present, the study of long-distance links based on IEEE 802.11 has been approached by several academic and research institutions. Also, the concept of free software has been applied to wireless connectivity devices such as routers and access points. The results of these studies have allowed us to join a low-cost device such as the Linksys WRT54Grouter to DD-WRT firmware, with the purpose of implementing a link between the National University of Loja and the Villonaco Hill. In addition, supporting tools were used in two ways: *Radio Mobile* helped us to determine the feasibility of the link, the orientation of the antenna, loss in space, etc, and PING command, allowed us to evaluate the response of the network implemented.

II. WILD NETWORKS

The IEEE 802.11 standard (WiFi) was designed for wireless broadcast environments with many hosts in close vicinity competing for channel access.

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Wireless radios are half-duplex and cannot listen while transmitting; consequently, a CSMA/CA (carrier-sense multiple access/collision avoidance) mechanism is used to reduce collisions. Unlike standard WiFi networks, WiFi-based Long Distance (WiLD) networks use multi-hop point-to-point links, where each link can be as long as 100 km.

To achieve long distances in single point-to-point links, nodes use directional antennas with gains as high as 30dBi, and may use high-power wireless cards with up to 400mW of transmit power. Additionally, in multihop settings, nodes have multiple radios with one radio per fixed point-to-point link to each neighbor. Each radio can operate on different channels if required. This is different from standard 802.11 networks where nodes route traffic through an access point and contend for the medium on a single channel. [1]

III. LINK BUDGET

For link planning, a link budget is prepared that accounts for the transmitter effective isotopic ally radiated power (EIRP) and all of the losses in the link prior to the receiver [2]. Depending upon the application, the designer may also have to compute the noise floor at the receiver to determine the signal level required for signal detection.

The link budget is computed in decibels (dB), so that all the factors become terms to be added or subtracted. [3]

The Radio Mobile is a tool used to predict the performance of a radio system.It uses digital terrain elevation data for automatic extraction of path profile between an emitter and a receiver.This data is added to system, environmental and statistical parameters to feed the Irregular Terrain Model radio propagation model.[4] Figure 1, shows the two point locationsin the link.

- *Point 1: National University of Loja* (2200 m.s.n.m.)
- *Point 2:* Villonaco Hill (2946 m.s.n.m.)

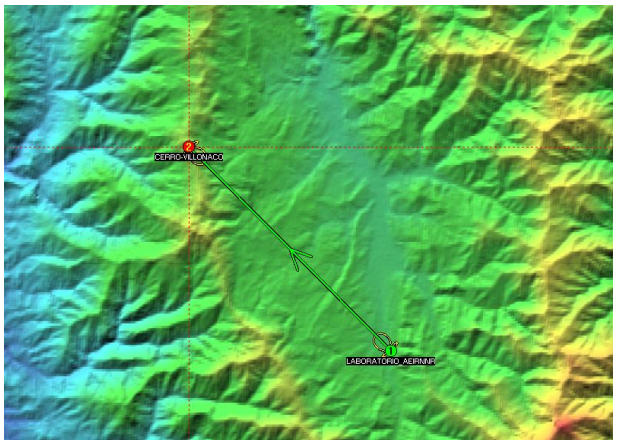

Fig. 1: Radio Mobile Location

Figure 2, shows the Radio Mobile parameters such as:

- *Tx, RxPower*
- *Loss*
- *Antenna Gain*

- *Antenna heigth*

These parameters allow us to know the Link Budget.
In addition, Radio Mobile lets us know the terrain profile and values of the Fresnel zone at each point of the link.
This can be seen in Table 1.

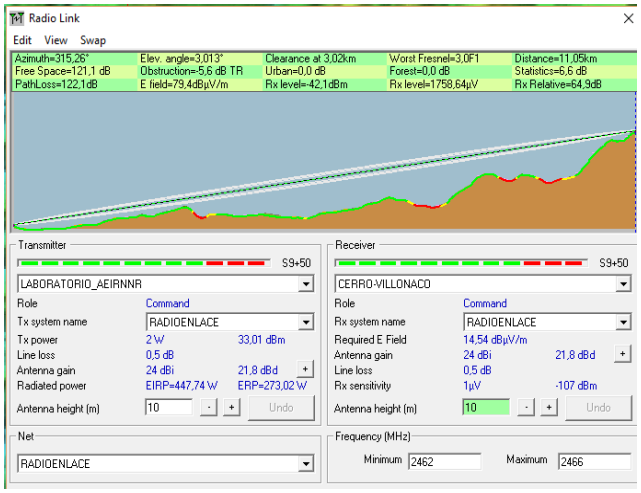

Fig 2.: Link Budget Parameter

Table 1.Values Fresnel zone

Dist. (Km)	hs(m)	hk(m)	ho(m)	C
0	2134	0	0	910
0,5	2125	1,72261484	14,7966374	916,997724
1	2149	3,41578327	20,8359877	891,024895
1,5	2177	5,0795053	25,4085363	861,081512
2	2227	6,71378092	29,2114101	809,167575
2,5	2240	8,31861013	32,5157911	794,283085
3	2303	9,89399293	35,4613069	729,428041
3,5	2257	11,4399293	38,131212	773,602444
4	2257	12,9564193	40,5799434	771,806293
4,5	2310	14,4434629	42,8454397	717,039588
5	2323	15,9010601	44,9554116	702,30233
5,5	2281	17,3292108	46,9308405	742,594518
6	2310	18,7279152	48,788072	711,916153
6,5	2320	20,0971731	50,5401383	700,267234
7	2373	21,4369847	52,1976304	645,647761
7,5	2478	22,7473498	53,769295	539,057735
8	2600	24,0282686	55,2624555	415,497155
8,5	2746	25,2797409	56,6833159	267,966022
9	2845	26,5017668	58,0371868	167,464335

Being C the value of the clearance that has the main beam from the first Fresnel zone.

IV. FIRMWARE DD-WRT

DD-WRT is a Linux based alternative Open Source firmware suitable for a great variety of WLAN routers and embedded systems. The main emphasis lies on providing the easiest possible handling while at the same time supporting a great number of functionalities within the framework of the respective hardware platform used.[5] DD-WRT GUI can be seen in Figure 3.

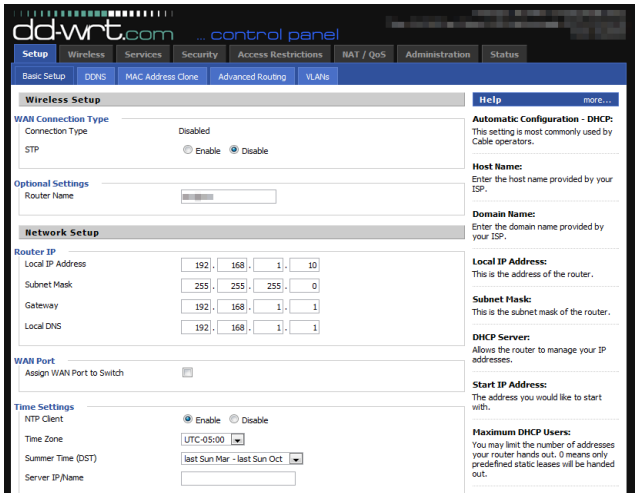

Fig.3: DD-WRT GUI

V. LINKSYS WRT54GROUTER

The Linksys WRT54Gisa Wi-Fi capable residential ateway from Linksys. The device is capable of sharing Internet connections among several computers via 100 Mbit/s 802.3 Ethernet and 802.11b/gwireless data links. The firmware used in these units varies between versions. According to Open Wrtdevices in the Linksys WRT54G series use various processors, which are all 32-bit architecture procesos and manufactured mostly by Broadcom.[6] The WRT54G router is shownin figure 4.

Fig. 4: Linksys WRT 54 g

VI. RADIO LINKIMPLEMENTATION

For the radio link implementation, the scheme shown in Figure 5 was used:

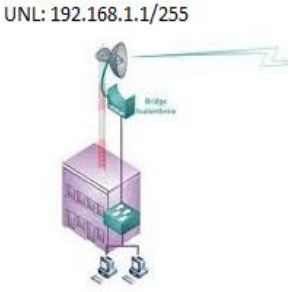

Fig. 5: Radio Link Scheme

In this implementation the following elements were used:

- *Villonaco Hill:*
  - *Linksys WRT54G Router Prx = 251 mW*
  - *GrillAntenna G=24 dBi*
  - *LMR200 Pigtail,5m, N to RP-SMA Type*
  - *EIA/TIA 568BPatchcord*
  - *Laptop*
- *National University of Loja:*
  - *Linksys WRT54G Router Prx = 251 mW*
  - *Grill Antenna G=24 dBi*
  - *LMR200 Pigtail, 5m, N to RP-SMA Type*
  - *EIA/TIA 568B Patchcord*
  - *Laptop*

Figure 6 shows an image of the whole antenna-tower on the Villonaco Hill.

Fig. 6: Tower in Villonaco Hill

VII. RESULTS

To evaluate the results the PING command was used, this command is part of the ICMP protocol and allows us to check the status of the link from our host in the National University of Loja (192.168.1.1) to the remote host located in the Villonaco Hill (192.168.1.10).

We can see these results in Figure 7.

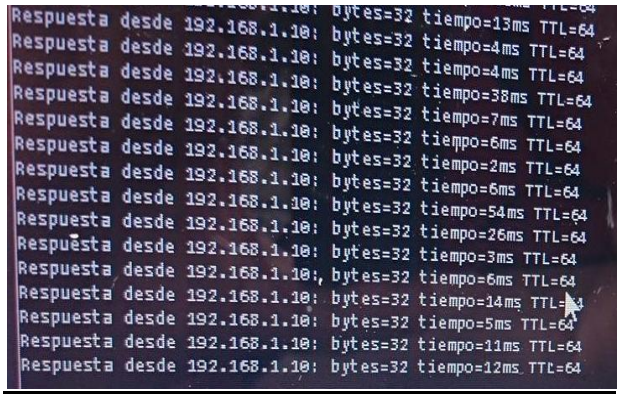

Fig. 7: PING Command

VIII. CONCLUSIONS

Futuros trabajos pueden desarrollar pruebas de otro tipo de tráfico, como voz y video sobre el enlace implementado.

This paper allowed us to deeply know the Radio Mobile software planning, as a tool for evaluating the feasibility of a radio link. Apply the experience of organizations such as TIER, ICTP and EsLa Red Foundation, in the study of WiFi-based Long Distance (Wild) networks, for implementing a radio link between the National University of Loja and the Villon co Hill. Use free firmware like DD-WRT, and low-cost hardware like the Linksys WRT54G, in the present case. Future work may develop evidence of other types of traffic, such as voice and video over the implemented link.

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