# Rehabilitation of an Internet network in 40 schools in Nabón, Ecuador

## Rehabilitación de una red de internet en 40 escuelas en Nabón, Ecuador

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## Keywords

Internet; sustainable development; maintenance engineering; Internet in rural areas; digital gap; wireless technology.

## Abstract

Internet access is necessary to ensure respect for the right to education, however, worldwide about 75% of school-age children in rural areas do not have access to the Internet at home, which makes it imperative the need for actions to reduce the digital gap to improve the quality of education in rural communities in Ecuador. This article describes the rehabilitation of an Internet network of 40 schools in the Nabón community, Ecuador. An earlier initiative implemented the Internet network, but lack of maintenance left it non-functional. With the support of the Municipality of Nabón, Motorola Foundation and IEEE SIGHT, a group of volunteers from IEEE Ecuador evaluated the state of the network to identify opportunities using the existing infrastructure. The commitment to the community, as well as the development of capacities, are at the center of the intervention to guarantee the sustainable development of the project. This document reports on the design, implementation, achievements and lessons learned from the rehabilitation of the Internet network.

## Palabras clave

Internet; desarrollo sostenible; ingeniería de mantenimiento; Internet en zonas rurales; brecha digital; tecnología inalámbrica.

## Resumen

El acceso a Internet es necesario para asegurar el respeto del derecho a la educación, sin embargo, en todo el mundo alrededor del 75% de los niños en edad escolar de las zonas rurales no tienen acceso a Internet en el hogar, lo que hace imperativa la necesidad de acciones que permitan reducir la brecha digital para mejorar la calidad de la educación en las comunidades rurales del Ecuador. Este artículo describe la rehabilitación de una red de Internet de 40 escuelas en el cantón Nabón, Ecuador. Una iniciativa anterior implementó la red de Internet, pero la falta de mantenimiento la dejó no funcional. Con el apoyo del Municipio de Nabón, Motorola Foundation e IEEE SIGHT, un grupo de voluntarios de IEEE Ecuador evaluaron el estado de la red para identificar las oportunidades utilizando la infraestructura existente. El compromiso con la comunidad, así como el desarrollo de capacidades, están en el centro de la intervención para garantizar el desarrollo sostenible del proyecto. En este documento se informa sobre el diseño, implementación, los logros y las lecciones aprendidas de la rehabilitación de la red de Internet.

## Introduction

According to ITU and UNICEF, about 75% of school-age children in rural areas do not have access to the Internet at home, compared with about 60% of school-age children in urban households [1]. In the Ecuadorian context, according to the Multipurpose ICT Survey, 54.5% of homes nationwide did not have internet access, 43.9% correspond to the urban area and 78.4% to the rural area [2].

For children and young people who do not have access to the Internet and are affected by the closure of schools due to the COVID-19 pandemic, education may be out of reach, even before the pandemic, more and more young people needed to acquire digital skills to be able to compete in the economy of the XXI century [3].

These data show the need for actions to reduce the digital gap to improve the quality of education in rural communities in Ecuador.

Although Internet network implementation projects in rural areas can provide great engineering characteristics, the solution proposed in this paper focuses on rehabilitation of an Internet network given the existing infrastructure on site and the economic limitations associated with the budget available.

## Project description

The objective of this project was to rehabilitate the internet network of 40 schools in the Nabón community and train members of the local community in the proper use and maintenance of the internet network. This will reduce the digital gap and support the sustainable development of the community.

### Background of the Nabón community

Nabón is a canton located southeast of the Azuay province, southern Ecuador, as shown in figure 1. Nabón has an area of 668.2 km$^2$, one of its geographical characteristics is the dispersion of its territory, which prevents easy access to different communities and makes communication between them difficult. Nabón has a population of 15,121 inhabitants distributed as follows: 6.9% in the urban area and 93.1% in the rural area. About 23% of the population is illiterate and the average schooling in rural areas is only 3.6 years. Nabón is considered the ninth poorest canton in the country, with 87.9% poverty and 55.7% indigence [4].

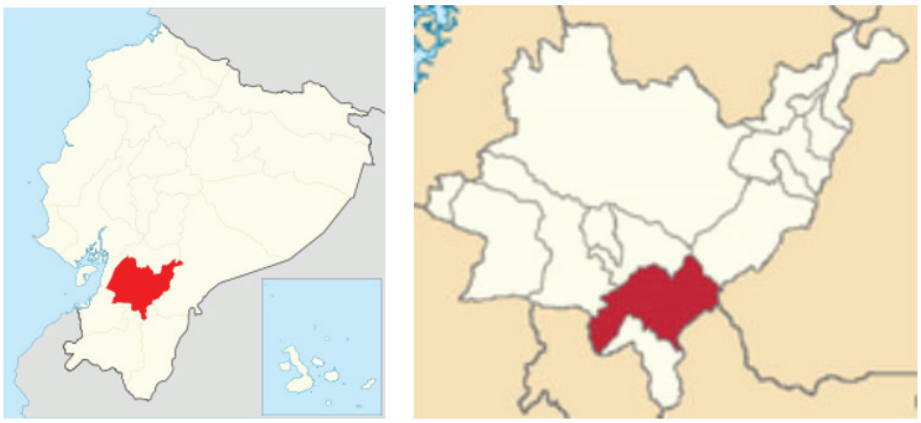

**Figure 1.** Geographical location of the Nabón canton. Source: [4].

### Description of the past system

In 2008, the National Telecommunications Secretariat of Ecuador and the Municipality of Nabón signed a cooperation agreement for the implementation, deployment and management of an internet network for 60 educational units. In 2016, the Ministry of Telecommunications of Ecuador transferred to the Municipality of Nabón the domain in perpetuity and free of charge of all the equipment of the internet network implemented.

The Nabón internet network is based on long-range WiFi wireless technology and its topology includes four elements: service node, backbone network, access networks and terminal equipment, as shown in the block diagram of figure 2.

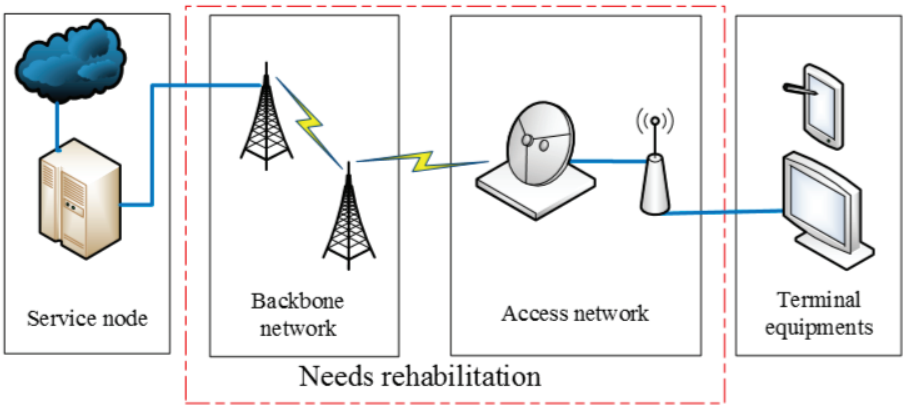


**Figure. 2.** Nabón network topology. Own source.

- The services node is located in the facilities of the Municipality of Nabón. The Internet service provider is CNT, which provides a bandwidth of 20 Mbps.
- The backbone network is made up of 7 radio links that should ensure an internet speed of 20 Mbps.
- The access networks in each school are made up of receiving antennas and wireless access points that should ensure an internet speed of 256 Kbps.
- The access points in each school are made up of desktop computers. The number of computers in each school varies between 1 and 8.

### Motivation and objectives of the Project

This project aims to rehabilitate the Internet network of 40 schools in the Nabón canton, which will allow students and teachers to improve the quality of education. The long-term objective is that all the communities of the Nabón canton have Internet service in their schools. In addition, it could be considered in the future that the network will also be used by the community in general, in applications such as telemedicine and electronic commerce.

### Cooperation and sustainable development

One of the main causes why Information and Communication Technologies projects fail has its origin in stakeholder management [5]. To minimize the potential failure of this initiative, the principle of co-creation is followed, in which the interested parties are actively involved in the implementation of the project, receiving the appropriate training, and making the community members maintain the solution by themselves.

## System design

The project aims to rehabilitate the Internet network by identifying opportunities that allow to take advantage of the existing infrastructure, considering the economic, legal, geographical and environmental limitations. Therefore, the project team assesses the current situation of the Internet network.

In this evaluation it was concluded that the Internet network of Nabón does not work in 40 schools due to problems in the active equipment of 5 of the 7 radio links of the backbone network: Nabón - Arverjilla - Huasiloma - Caraylo - Bayan, as shown in the figure 3; as well as problems in the active equipment of the schools' access networks are also identified.

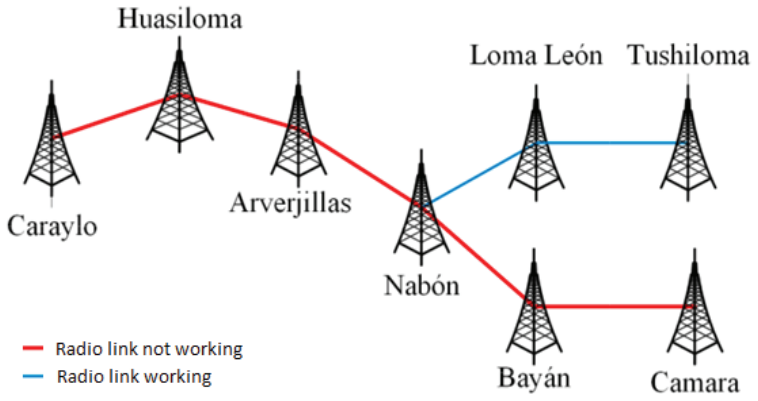


**Figure. 3.** Past situation of the backbone network. Own source.

Due to the unavailability of the installed equipment in the market and the fact that it is not possible to combine the radio link technologies due to incompatibility between the master and slave equipment, the complete rehabilitation of 5 radio links is necessary to put the backbone network into operation. In addition, it is necessary to carry out the rehabilitation of the 40 access networks for each of the schools.

For the calculation of radio links, parameters such as: line losses, propagation and power losses and receiver sensitivity are considered. From this, the active equipment of the network is dimensioned: point - point antennas, point - multipoint antennas and receiving antennas, for the Internet network.

To calculate the bandwidth required for the network, the capacity needed for each school is added and the result is divided for the level of sharing required. The necessary capacity for each school, according to the number of users is 10 Mbps, while the level of sharing for each link is 4 to 1. Therefore, the bandwidth required for the Internet Network in 40 schools is 100 Mbps.

## Project implementation

### Rehabilitation of the internet network

Based on the design of the system, the acquisition of equipment such as antennas, routers, wireless cards, network cable and other accessories is carried out; In addition, the necessary logistics are coordinated to carry out the work in 3 interventions, which included the work of volunteers from IEEE Ecuador, volunteers from Motorola Foundation and technicians from the Municipality of Nabón.

The rehabilitation of the backbone network consists of the installation of active equipment and its components in the Nabón, Arverjillas, Huasiloma, Caratlo and Bayan links. The rehabilitation also included the installation of a tower for the equipment located in Arvejillas and the preventive maintenance of the other towers.

The project team made the necessary arrangements with the Internet service provider to increase the network bandwidth from 20 Mbps to 100 Mbps, without adding the cost of the service to the Municipality of Nabón.


**Figure. 4.** Project team in the rehabilitation of the backbone network. Own source.

The rehabilitation of the access network consists of the change of receiving antennas, routers, network cables and other accessories for the 40 schools that are part of the Internet network and, in some cases, included the change of antenna masts and cards. wireless network of computers. The rehabilitation in each school also included the preventive maintenance of hardware and software of the terminal devices of each of the schools. Through the measurement of internet speed in each school, the adequate levels of bandwidth for each access network are verified.

**Figure. 5.** Volunteers installing access networks. Own source.

In order to ensure the sustainability of the network over time, four technicians from the Municipality of Nabón were trained in the management and maintenance of the Internet network, this will allow the continuous operation of the network and the solution of technical problems in less time.

### Achievements and lessons learned

The participation and commitment of the community in the implementation of the project were essential for the successful completion of the rehabilitation process.

Given the restrictions due to the COVID-19 pandemic, adaptation to the new conditions in the implementation of this type of project was essential to meet the objectives of the rehabilitation of the Internet network.

The rehabilitation of the Internet network in 40 schools in the Nabón community has allowed around 2,400 students to have access to the Internet to improve their quality of education. This project had a greater impact by allowing access to virtual education to students during the COVID-19 pandemic.

**Figure. 6.** Beneficiaries of the project using the Internet network.

## Conclusions and future work

An evaluation of the current state of the previous systems was carried out, identifying opportunities in the existing infrastructure. This evaluation showed the availability of the civil and electrical infrastructure, but also showed that the active equipment of the backbone network and the access networks had to be replaced and that training is necessary for the technical staff of the community for the management and maintenance of the network.

The Internet network for 40 schools in the Nabón community was successfully rehabilitated. Community members, mainly children, have taken advantage of the Internet to access virtual education during the COVID-19 pandemic.

This project can serve as a model that can be replicated in 8 Internet networks identified in other rural areas of Ecuador that are not operational. The project team is working on the next phase that seeks to rehabilitate the internet network in 20 schools. The authors are also working on evaluating the project's Social Return on Investment (SROI).

## Acknowledgments

This work was supported by IEEE through a grant from IEEE SIGHT. This project was also partially supported by the Municipality of Nabón, the Motorola Foundation, the IEEE Young Professionals program and the Universidad Politécnica Salesiana de Cuenca. In addition, the authors thank the 35 volunteers from IEEE Ecuador and the Motorola Foundation, for their contribution during the rehabilitation of the Internet network in the Nabón community.

## References

[1] United Nations Children's Fund (UNICEF) and International Telecommunication Union (ITU), How many children and young people have internet access at home? [Online]. Available: https://www.unicef.org/reports/how-many-children-and-young-people-have-internet-access-home-2020.

[2] World Economic Forum, Report on the future of employment 2020. [Online]. Available: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

[3] Decentralized Autonomous Government of the Nabón Canton, Data from the Nabón canton. [Online]. Available:http://www.nabon.gob.ec/datos-del-canton/#1523640018226-74bf08fb-7866

[4] National Institute of Statistics and Censuses of Ecuador (INEC), "Multipurpose ICT Survey", [Online]. Available: https://www.ecuadorencifras.gob.ec/tecnologias-de-la-informacion-y-comunicacion-tic/.

[5] K. Fenech and C. De Raffaele, "Overcoming ict project failures- a practical perspective," in 2013 World Congress on Computer and Information Technology (WCCIT). IEEE, 2013, pp. 1–6.

# Rehabilitation of an Internet network in 40 schools in the Nabón community, Ecuador.

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## 1. Introduction

In Ecuador, only the 22% of homes in rural areas have internet access. This show the need for actions to reduce the digital gap to improve the quality of education in rural communities.

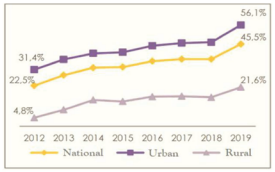


Fig. 1. Percentage of houses with internet access, by area, in Ecuador.

In 2008, the government of Ecuador and the Municipality of Nabón implemented an Internet network for 60 schools. The internet network is based on long-range wireless technology and its topology includes: service node, backbone, access networks and terminals., as shown in the Fig. 2.

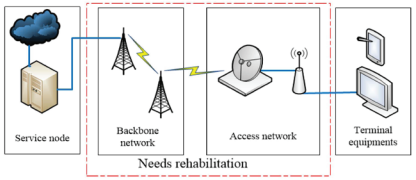


Fig. 2. Nabón network topology.

This project aims to rehabilitate the Internet network of 40 schools in the Nabón canton, which will allow students and teachers to improve the quality of education.

## 2. Design of the proposed network

An evaluation concluded that the network does not work in 40 schools, due to problems in 5 radio links of the backbone network: Nabón – Arverjilla – Huasiloma – Caraylo – Bayan - Camara, as shown in Fig. 3.

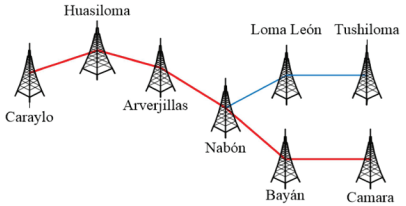


Fig. 3. Current situation of the Nabón Internet network.

For the calculation of radio links, parameters such as: line losses, propagation and power losses and receiver sensitivity are considered.

To increase the bandwidth of 0.25 Mbps to 10 Mbps for each school, management is carried out to increase the capacity of the network from 20 Mbps to 100 Mbps, without adding costs to the operation of the network.

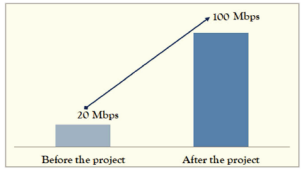


Fig. 4. Increase the bandwidth in the Nabón Network.

## 3. Implementation

The necessary logistics are coordinated to carry out the work in 3 interventions, which included the work of volunteers from IEEE Ecuador, volunteers from Motorola Foundation and technicians from the Municipality of Nabón.

Fig.5. Backbone and access network installation.

The rehabilitation in 40 schools in the Nabón community has allowed around 2,400 students to have access to the Internet to improve their quality of education. This project had a greater impact by allowing access to virtual education to students during the COVID-19 pandemic.

To ensure the sustainability of the network, four technicians from the Municipality of Nabón were trained in the management and maintenance of the Internet network.

Fig. 6.. Technicians from the Municipality of Nabón in the training.

## 4. Conclusions / Next Steps

- An evaluation showed the availability of the civil and electrical infrastructure, but also showed that the active equipment of the backbone network and the access networks had to be replaced and that training is necessary for the technical staff of the community for the management and maintenance of the network.
- The Internet network for 40 schools in the Nabón community was successfully rehabilitated. Community members, mainly children, have taken advantage of the Internet to access virtual education during the COVID-19 pandemic.

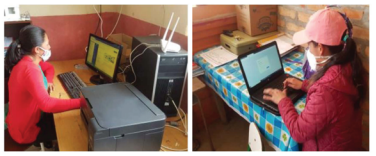

Fig. 7. Beneficiaries of the project using the Internet network

- This project can serve as a model that can be replicated in 8 Internet networks identified in other rural areas of Ecuador that are not operational. The project team is working on the next phase that seeks to rehabilitate the Internet network in 20 schools. The project team are also working on evaluating the project's Social Return on Investment.

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**Ilustration 1.** Presented Poster at LAEDC 2021.