Where There Is No Internet: Experiences from Rural Honduras

2013 - 2015: Phase I Implementation

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Abstract—**ACTS is a non-profit organization based in Norwich, Vermont. Since 1986 ACTS has partnered with rural villages in the mountainous Locomapa region of the Yoro district of Honduras with a focus on sustainable community development. In a region where a 6th grade education is the norm, a major initiative of ACTS has been improving educational opportunities.**

In 2008 ACTS helped the community of El Rosario open a community library. To help expand their offerings we have investigated ways to bring technology to the community. As part of this effort we have partnered with the community to install two wireless networks that serve educational content, such as Wikipedia, e-books, and Khan Academy videos. The long-term plan for this initiative is to continue installing self-contained educational nodes, connect each node to form a community mesh network, and eventually connect this network to the Internet. Community feedback and training has been a major part of this project and will be the key to its sustainability.

This case study will cover design considerations, implementation methods and lessons learned while working with the community. An emphasis will be given to the technical considerations, but will also cover the importance of community organization. We are still collecting information from the prototyping phase, and continue to work on plans to further scale the current deployment.

Keywords— ICT; ICT4D; Internet; Developing World; Education; Wireless Communication; Digital divide

I. INTRODUCTION

ACTS is a registered 501(c)3 non-profit organization based in Norwich, Vermont. Since 1986 ACTS has partnered with rural villages in the mountainous Locomapa region of the Yoro district of Honduras with a focus on sustainable community development. During this time, ACTS has built a medical clinic and bunkhouse in the village of El Rosario. Countless numbers of volunteers with various backgrounds, from doctors and dentists to teachers and students, have stayed in the bunkhouse and worked with the people of El Rosario and surrounding communities.

For over 25 years ACTS has worked with the people of El Rosario to improve their quality of life. The children of the community are no longer plagued with the consequences of contaminated water, and the men and women of the community have been given new opportunities to manage their community's growing infrastructure. More recently ACTS opened a regional library and education center, which the community dedicated to Dr. Dean Seibert, a long standing ACTS volunteer that has been traveling to the area for over 20 years.

II. OBJECTIVES

Access to educational opportunities in this region of Honduras are limited. While each village has a small one-room school and offers coursework through the sixth grade, when students graduate they often lack the skills necessary to pursue further education.

Students in the nearby communities that are able to graduate from their local school can apply to attend a private secondary school, which a partner non-government organization opened in 2009 and provides curriculum through the ninth grade. This school offers a computer laboratory and library for its students, but is generally not open to the public or students outside school hours.

The regional library in El Rosario provides some additional resources for students, teachers, and community members. In some cases teachers from surrounding communities will walk with their class for over an hour to visit the library. The goal of this public library is to cater to both students and adults by providing books for a wide range of audiences, with a specific focus on educational texts and trade skills. In addition to books, the library offers access to limited computer resources and a printer.

Since there is no Internet connection within the village and cell coverage is extremely minimal, communication can be difficult. While many educational materials have been pre-loaded on the computers, the content available is limited due to the lack of telecommunications infrastructure.

The need in this area can be summarized into three main categories:
1. Improved educational resources
2. Extension of communication channels to be able to access information and communicate with the rest of the world
3. Organization and ownership of implemented systems

These needs have been used as the driving force behind a multi-phased plan to provide the people of El Rosario and the surrounding communities the opportunity to bridge the digital divide.

III. DESIGN

The multi-phased approach to this plan provides the framework to show early tangible results, while also setting a loose framework to allow for iterative revisions based on lessons learned during implementation. The initial plan has three main phases, but is expected to change as the communities provide feedback. The three phases are as follows:

1. Provide additional educational content at the community education center using computers and a small wireless network.
2. Expand the wireless network to include other sites within El Rosario, including the schools and medical clinic. Identify communities interested in similar services.
3. Expand the wireless network to connect schools in nearby villages. Install a wireless repeater to connect the network to a local Wireless Internet Service Provider (WISP).

Each of these phases has distinct tangible results, and all phases will have an emphasis on improving computer literacy and overall system operation and maintenance.

Usability will be an important factor in the design process but even with this consideration, training local community members to operate and maintain their systems will be vital for the long-term success of this project. Throughout the design and implementation of this program training sessions will be held with interested community members and feedback will be solicited as much as possible.

IV. IMPLEMENTATION

Groups of ACTS volunteers travel to El Rosario multiple times a year to focus on a variety of projects. Each group generally has 3-12 volunteers who stay in El Rosario between 5-12 days. This paper focuses on the work done during three such trips, detailed in **Table 1**.

A. Computers

Before officially beginning the technology project described in this paper, various ACTS volunteers brought computers to the education center. During the initial assessment in June 2013, the education center had two desktop computers, an iMac that was approximately 6 years old, and an older Power Mac G4 tower. Two Spanish keyboards were purchased during this trip to replace the existing English keyboards. An additional 17" MacBook Pro was donated to the education center during this trip. This system was approximately 7 years old, no longer had a battery, and had an English keyboard.

During the November 2014 trip ACTS purchased four new laptops in San Pedro Sula, Honduras to be used at the El Rosario education center. These laptops provided some

TABLE 1: TRAVEL DATES

Date	Description
June 2013	• Initial assessment of community education center • Loading educational content on existing computers • Training with area teachers
November 2014	• Installation of educational content on wireless network at education center • Configuration of 4 new laptops for education center • Training with librarian • Formation of El Rosario Technology Committee
April 2015	• Monitoring wireless network at education center • Training with area teachers • Installation of educational content on wireless network at medical clinic • Meeting with El Rosario Technology Committee • Meeting with WISP

advantages over the existing computers, including Spanish keyboards and working batteries.

When possible, Ubuntu variants were installed as the operating system for the computers. During the June 2013 trip Lubuntu 13.10, a lightweight version of Ubuntu, was installed on all the existing computers except the Power Mac G4. During the next trip in November 2014, Edubuntu 14.04 LTS was installed on the new computers; additionally the existing laptop was upgraded from Lubuntu 13.10 to Lubuntu 14.04.

Standardizing on Ubuntu provided the ability to pre-package an application mirror that could be used to install additional applications during the trip without needing an Internet connection or licensing. Version 14.04 is a Long Term Support release of Ubuntu, which will be more sustainable than the original 13.10 installations. Additionally, Edubuntu provided a number of educational applications pre-installed with the operating system, which were previously installed manually with Lubuntu.

B. Educational Content

During the initial June 2013 trip an archived copy of Spanish-language Wikipedia was installed on each Ubuntu-based system using an application called Kiwix. Additional educational applications were installed on each of these systems.

During later trips, a network-based solution called *Remote Areas Community Hotspots for Education* (RACHEL) was used to provide similar content via a wireless network connection. This system has a Raspberry Pi computer at its core which runs a system image provided by the non-profit organization, World Possible (http://worldpossible.org/). The system images provided by World Possible are organized by language and system size and provide offline access to an archived copy of Wikipedia, as well as Khan Academy videos, and a number of educational documents. The system image used for this installation was later modified for the April 2015 trip to provide a combination of English and Spanish resources on the same Raspberry Pi.

C. WiFi Network

While the Raspberry Pi system provides much of the content and can act as an isolated wireless access point, the overall usability and scalability of this approach is limited. To address these concerns, the Raspberry Pi was paired with a router and wireless access point.

An Ubiquiti EdgeRouter PoE 5 port switch was used for this installation. Beyond providing traditional router functionality, such as network address translations (NAT) and dynamic host configuration protocol (DHCP) services, the router was also configured to act as a name server for the local network. An instance of BIND was installed on the router and configured with zone files that had a number of CNAME records pointing to the same statically defined IP address for the Raspberry Pi.

In addition to software-defined services, the router also provided the benefit of configurable Power over Ethernet (PoE). The PoE functionality was used on one port to power a Ubiquiti Unifi AP Outdoor access point. This access point was chosen because it runs on 48V PoE and did not require an additional power cable, and while it is operating indoors, the conditions are still harsh so the outdoor rating may help extend its operating life.

Two additional PoE antennas could be configured on the router to allow for future growth, but were not included in the current installation. These antennas could be used to install additional access points, allowing extended wireless coverage and in turn potentially more users, or to connect to a point-to-point antenna with a WISP or other educational node. **Fig. 1** shows a diagram of the network we installed at the library, which we left with the librarian for reference.

D. Cellular Network

While there is currently very limited cellular service in the area around El Rosario, two cellular providers, Tigo and Claro, have been expanding their networks in the region over the past 10 years. Many of the communities ACTS works with are situated in a valley and the surrounding mountains shade the area from the recently installed cell towers.

To better understand the cellular coverage, signal readings were collected for the Claro network during the November 2014 trip and Tigo data were collected during the April 2015 trip. An Android application called GMon was used to collect GSM signal strength data and corresponding GPS coordinates.

During the April 2015 trip, a GSM Cellular booster was installed in the medical clinic. The cellular booster consists of an outdoor high-gain directional antenna, which is pointed in the direction of a cellular tower. The outdoor antenna is then connected to an amplifier situated in the medical clinic. After the signal is boosted, a second indoor antenna is connected to the amplifier to provide cellular signal in a small indoor area. **Fig. 2** depicts the signal strength we recorded for three separate cell towers as seen at the medical clinic using the cellular booster while slowly changing the azimuth of the directional antenna.
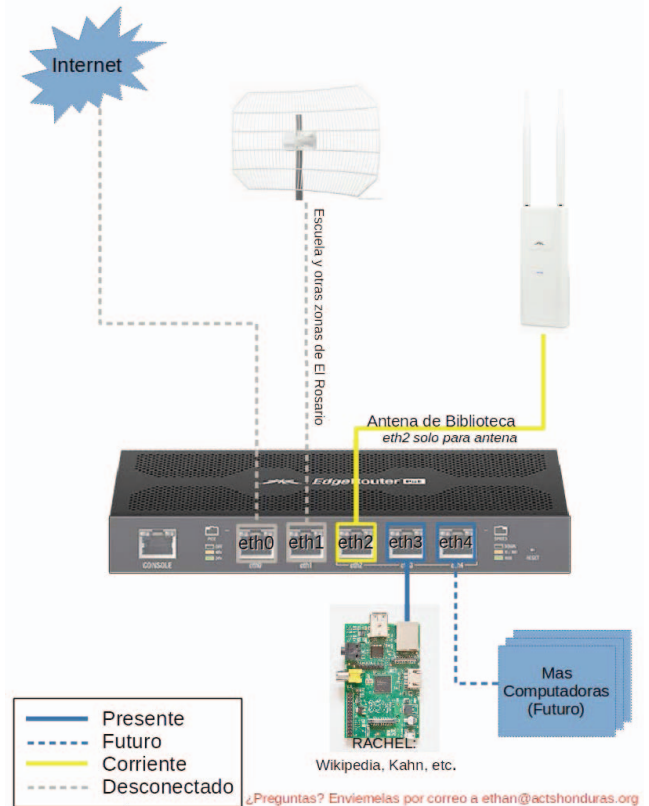

Fig. 1: Pictorial representation of wireless system installed at the education center.

E. Training

During the June 2013 and April 2015 trips an afternoon training session was held at the El Rosario education center for teachers from the surrounding community. In total, 11 communities were represented during these trainings. ACTS volunteers with education backgrounds organized much of the logistics of these trainings, which all had a majority focus on the new technology offerings at the education center.

The training during the June 2013 trip focused on many computer basics, such as using a mouse and keyboard, opening and closing applications, and how to use the new archived copy of Spanish-language Wikipedia.

The April 2015 training was taught by the librarian. During this session he covered how to turn the laptops on and off, how to create, format and save documents, and how to use the web browser to access the information on the wireless network.

The librarian also informed the teachers of the classes he was teaching during the week that covered word processing and spreadsheets. These classes are mainly attended by students from El Rosario, but are open to all who wish to attend.

In addition to training educators and opening the library resources to the community, training on system operation and maintenance will be key to its longevity. During the November 2014 trip a community technology committee was formed. The committee has representatives from the Health and Development Committee, the local private school, the
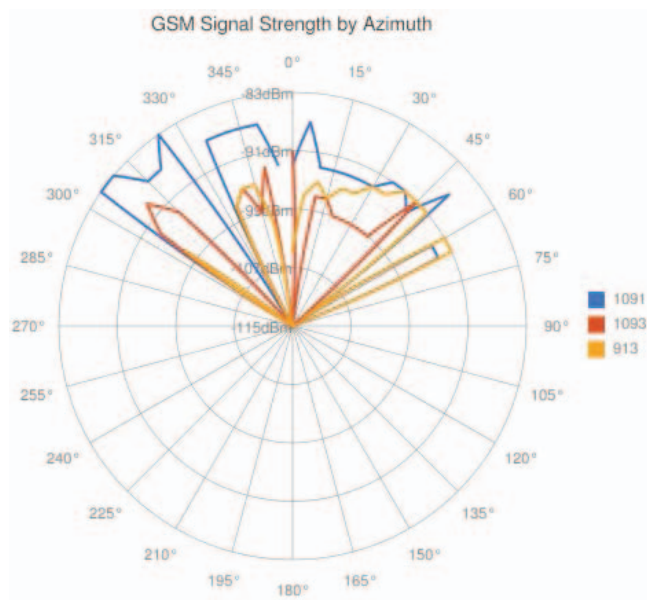
Fig. 2: GSM signal strength recorded at the medical clinic when using a cellular amplifier

micro bank, and the education center librarian. The mission of the committee is to drive the future direction of information and communication technology in El Rosario and the surrounding area.

V. OBSERVATIONS

A. Computers

Standardizing on an open source operating system, such as Ubuntu, has made it much easier to find software and install Spanish language packs. While some of the software may not be exactly the same as what other ACTS volunteers have experience with, avoiding software licensing and activation has reduced the hassle with installing applications and has reduced the overall cost of the system. A number of free educational applications are also available, which has proved very useful in the education center.

Since Ubuntu's advanced package tool (apt) generally relies on an Internet connection to download packages, part of the pre-trip planning involves downloading the entire repository for Ubuntu 14.04's "Trusty" distribution. This is made fairly trivial using an application called apt-mirror, which will mirror all packages defined in a configuration file. As USB storage becomes more economical, storing these packages will become more practical. For each of these trips a 128GB USB stick was pre-loaded with the needed packages.

The systems donated before the June 2013 trip have all failed. Instead of bringing down old donated equipment, ACTS has now focused on providing quality equipment to help reduce the overall maintenance burden. Desktop systems will no longer be used and only laptops with batteries will be considered for purchase or donation. During each of the three trips discussed in this paper, the power went out for greater than 2 hours on at least three occasions each trip. Battery

backups, for both the laptops and network, are important factors in their resilience.

B. Library Usage

Seasonally the library is closed from mid-November through February. This coincides with the school break, as school-aged children are the main patrons of the library. The previous librarian did not return after the 2014-2015 break, so the El Rosario Education Committee initiated a search for a new librarian. A primary focus of their search was to identify a candidate with computer experience.

The committee hired a new librarian in February but unfortunately there was no overlap with the previous librarian. The new librarian has a high school education with a focus in accounting and administration. He attended a high school with a computer lab, but ACTS has been unable to visit the school on recent trips.

Through continued communication with the librarian, we have collected information about the monthly library usage. Each month we now receive a tally of total unique visitors and the services they used at the library. As seen in **Fig. 3**, the year over year attendance continues to increase monthly, from a 46% increase in March to 103% in June. The librarian indicates the people who do visit the library any given month do so on a regular basis. The increased access to computers and trainings provided by the librarian are thought to be the main factors increasing usage, which is supported by the large portion of the library patrons utilizing the computer resources, as shown in **Fig. 4**.

C. WiFi Network

The wireless network remained in an operating state between the November 2014 and April 2015 trips. The operating temperature of the router and Raspberry Pi were extremely high, which was addressed during the April 2015 trip. Two USB powered fans were zip-tied to the top of the router in the education center and the medical clinic. While exact system temperatures before and after were not recorded, before this modification the case of the router was painful to touch for more than a few seconds, and after it remained approximately room temperature.
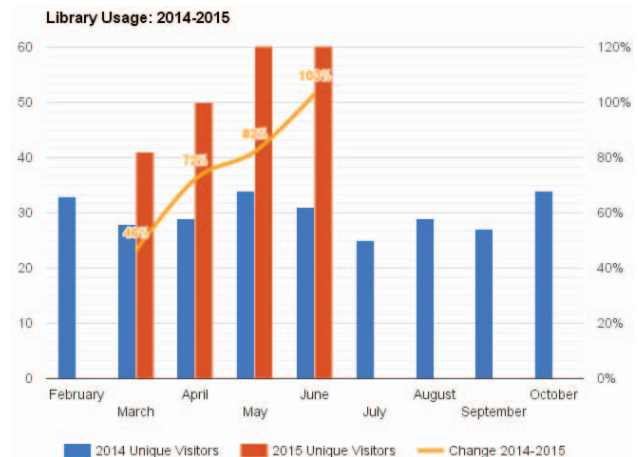

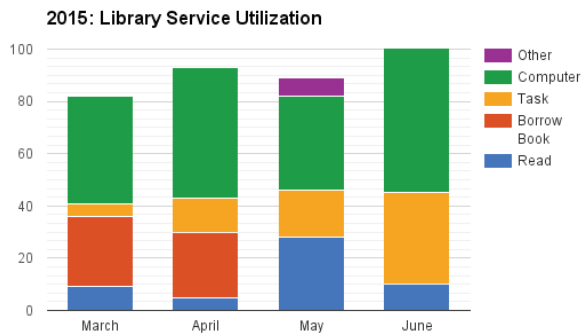Fig. 3: Monthly unique library visitors compared between 2014 and 2015

Fig. 4: Services provided by the community library between March and June 2015.

Both wireless networks in the education center and medical clinic are connected through an Uninterruptible Power Supply (UPS). This design choice has helped drastically reduce downtime, which is essential during trainings. Since coordinating volunteers and teachers from 11 communities is already logistically challenging, not having to worry about power outages has been very beneficial.

At the end of the April 2015 trip ACTS had a meeting with a WISP that provides service to communities in the Yoro district. After meeting with one of their antenna engineers it was determined that it should be possible to establish a 13km point-to-point link between one of the WISP's towers and a community located on the ridgeline just south of El Rosario. The signal could then be repeated into the valley where the El Rosario education center is located. This option will be discussed with the El Rosario technology committee in the coming months.

D. Training

Training will remain a common theme of all ACTS trips. While the current training focuses around how to use computers on the most basic level, certain members of the technology committee have received additional training on system operation and maintenance. While training is a common theme, it has occasionally been de-prioritized when time becomes constrained.

VI. CONCLUSIONS

Computers and WiFi enabled mobile devices are becoming much more common in this region of Honduras. Community members now have access to a vast amount of educational content through the computers at the education center as well as using personal WiFi enabled devices in the vicinity of the education center or medical clinic. Even though these networks are not yet connected to the Internet, they are providing a foundation to improve computer literacy in the region, while also providing much needed educational materials. While there is always risk that the devices may break or be stolen, especially due to their technical nature and compact size, efforts have been made to mitigate these risks.

Training and education are a vital part of success of this project, however, they can be easy to overlook. During the time when the ACTS volunteers are in the village, schedules can be very chaotic. Due to the nature and variety of ACTS projects, setting priorities and addressing every trip goal can be difficult. Additionally, language constraints and the number of people needed to conduct and attend trainings make trainings challenging to organize; however, when they are organized they are extremely well received.

In addition to the training performed with the community in Honduras, there is a large amount of training and preparation that is needed before each trip. Many of the members of ACTS do not have advanced technical skills, such as those needed to install an operating system or update and customize router firmware. To address these needs, ACTS has been recruiting support from partner companies, such as Dyn, to help plan and test implementations while also developing training materials to use with the Honduran community. ACTS does have a strong resource of current and former teachers, which will be leveraged to help develop a technical training curriculum for the benefit of both ACTS volunteers and the partner communities.

The new librarian demonstrated the importance of having a local asset that can be used to train others. Moving forward it will be important for ACTS and the community to continue to foster their relationship with the librarian and begin to identify additional local community members interested in learning more about the operation and maintenance of the overall system.

The phased approach of this project has allowed ACTS to provide tangible results, and use these as building blocks to start discussions about future plans for the system. Without these concrete examples, it has been difficult to talk about plans with community members in an abstract sense. While at times this does require ACTS to implement changes without consulting the community, the overall idea behind these changes are discussed and approved by the members of the technology committee before they are implemented. Additionally, the changes are usually relatively small and only provided as a proof of concept before scaling to a larger system. This method of implementation has been very helpful in gathering feedback from the community before making large investments.

Moving forward, the main goals of this project will remain the same. A major focus will be to provide educational opportunities, both through the act of learning how to use computers, and also with the content these systems provide. There are a number of directions this project could take, from advocating on behalf of the community for better cell service, to implementing a community wireless mesh network, or implementing an inter-community network. Additional time and data will be needed to assess the total impact of this project, but early observations show a reduction in the digital divide.