

Rationalisation of Heterogeneous Rural Internet Protocol Networks to Achieve Sustainability

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Abstract— Rural Internet Protocol networks are physically and logically like any other Internet Protocol network in urban areas. However, they face challenges regarding unreliable power, limited bandwidth and unqualified network support. Each factor results in lowering network availability. Related work indicates the importance of addressing these challenges as the key to the sustainability of such networks. In the rural Eastern Cape, we have an example of such a network run by a local non-governmental organisation. The network has two satellites that supply Internet connectivity, wired and wireless local area networks and long range wireless links connecting five rural villages. The research poses three questions: how can we use alternative power sources to keep network devices operational, what techniques can be used to manage bandwidth optimally, and how can we enable untrained locals to manage these rural networks? We will build prototypes to address these questions and test them on the network. Qualitative results will be collected from the users in semi-structured interviews, while quantitative data will be automatically collected from the network itself. The data will be analysed and the results will be used to measure and rationalise possible changes to achieve sustainability for the network.

Index Terms—Network management, Systems integration, Subscriber management, Fulfilment, assurance, billing.

I. INTRODUCTION

THE challenges faced in the design of sustainable rural Internet Protocol (IP) networks include power provision, technical issues, environmental factors and socio-cultural factors. [1, 2]. These differences cause rural networks to suffer from low availability, meaning that they are often not functional. Power is a vital requirement since network and client devices need electricity to operate. In many rural areas the supply of electricity is unreliable due to interruptions up to several weeks, or even a complete lack of infrastructure. One technical issue of great importance is the management of bandwidth, since it allows access to the Internet, which in turn provides access to additional resources and services. Since bandwidth is not a free resource, it should be conserved such that there is always access to the Internet. It is important to factor in the environment and how we can design rural networks to accommodate natural factors such as exposure to strong winds and rain. In order to implement a sustainable rural network we have to be aware of the socio-

cultural factors in rural communities. The level of technical knowledge relating to Information and Communication Technology (ICT) is quite low. Therefore, if we want locals to manage these networks, we need to provide mechanisms to empower them to do so.

The rest of the paper is organised as follows. Section II briefly describes work related to rural networks, their challenges as well as ways to address them. Section III addresses the experimental design of our study. Section IV concludes the paper and presents future work.

II. RELATED WORK

This section covers related work of several key issues in the same order as introduced in the previous section: provision of power, technical bandwidth management, environmental factors and empowering locals to manage rural wireless networks themselves.

There are various kinds of technology we can use to provide network access, but we have to choose the technology which takes the environment into consideration. We have to be socially aware of the ICT knowledge in rural areas in order to facilitate locals in the development of these rural networks.

Due to the unreliability of mains power in rural areas, it becomes important to power network devices using alternative sources of power [1]. Many WiFi devices do not require 220V and can be powered using lower voltages such as 12v, and can be provided by a car battery. Such batteries can easily be charged with solar panels. Solar panels work well in the case of unreliable power but batteries can also be trickle charged using mains electricity when it is available. Deep cycle 12v batteries can last longer than UPS systems that are frequently burned out by brown-outs common in rural mains power provision [1].

Bandwidth is a scarce and expensive resource, so we have to find and use bandwidth management techniques that best conserve the available bandwidth while still providing continuous access. Internet access that is not managed properly often leads to abuse [3]. Bandwidth is important since it provides access to the ‘outside world’ and to services that would otherwise be difficult for people to access. Passive bandwidth management, such as informing people that bandwidth should be conserved, helps, but active management is a stronger option.

The rural environment is very tough on networking equipment. Aside from causing frequent power outages, exposure to natural elements can cause equipment to malfunction. Wireless technologies are inexpensive and

advantageous for rural networks [4, 5]. Furthermore, many wireless components can be housed in weatherproof housings.

Rural networks can be maintained by firstly training local support staff to do the day-to-day maintenance activities and secondly by providing mechanisms by which individuals with more technical knowledge can access the network to provide advanced support [2]. When training locals, we must adjust training to their skill levels. As far as remote management goes, it is not always foolproof since we require the device that will accept the incoming connection to be operational when other parts of the network may be down.

III. EXPERIMENTAL DESIGN

At our research site in the rural Eastern Cape, there is currently much wireless infrastructure in place, spanning five rural villages. The infrastructure includes 2.4GHz and 5.8GHz long-range links, two VSAT uplinks and numerous omni-directional hotspot-style access points. The networking equipment includes many different makes and models. We intend to migrate the devices that currently run on mains power to the type of battery power mentioned above. These devices include the two VSATs and the router/hotspots at two of the villages as is done at the other three villages and relay points. Batteries will be charged using a combination of solar panels and mains power. Client devices are of less concern for power management since the majority of them are laptops and have built-in long-life batteries. We will collect metrics such as the amount of hours needed to charge a battery and the rate at which devices discharge the batteries in order to decide whether the use of batteries as an alternative source of power is sustainable or not.

Currently, a desktop PC is responsible for bandwidth management. Management will be migrated to a Mikrotik router powered by a 12v battery. The router has superior bandwidth management functionality, and multiple routers can be used to manage all of the hotspots across the network, including the two VSAT uplinks. The hotspot software can create guest user accounts to access bandwidth that must be purchased. Employees of the NGO (and a hospital at one village), on the other hand, will be 'given' cap-based access to the Internet.

At one site, we will move the VSAT and antenna closer to the location of the Mikrotik router such that they share power from a centralised battery array to lessen the need for lengthy cables and also provides a central location when the network needs to be configured. This move must also take into account the elements and the wireless antenna will be secured and positioned in the best manner possible.

We will train individuals associated to the NGO in a hands-on fashion. Firstly, we will create a local web server to store documents relating to the network such as network diagrams, manuals and comments such they are always available from anywhere on the network. Secondly, technical trainees will be able to edit the website such that when something new is learned it can be added. Lastly, a GPRS gateway will be set up which will allow for remote assistance.

IV. PRELIMINARY AND FUTURE WORK

A first visit by the lead author to the village where the NGO is headquartered led to the installation of hotspot management software on a desktop computer to control Internet access. The software was configured such that NGO employees were given unrestricted access to the Internet while guests had to purchase vouchers to gain access.

On a follow-up visit, we found that unreliable power precluded the hotspot server from functioning properly. It did not block access and everyone who could access the wireless network had access to the Internet. We also learned that because of this fact, the Internet cap was being reached three weeks into the month. We mapped out the wireless coverage to verify that all parts of the NGO campus were getting wireless coverage. We also took an inventory of the devices in the network and then based on this information, decided which devices are necessary for network availability and in turn which devices require alternative power.

Now, currently busy with a third visit, we will implement part of this study by implementing improved bandwidth management techniques using a Mikrotik router, moving the relevant equipment and implementing our strategy to provide local staff training and remote gateway installation.

On future visits we will migrate the identified devices to battery power. We will also collect the metrics as described above. We will, if necessary, alter the bandwidth management and associated requirements if bandwidth is still not found to be at optimal usage. We will also verify the ability of the web server to be used as a training tool and implement the GPRS gateway.

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