Exploring Cost-Effective Reinforcements for Rural Telecommunication Networks: Dwesa Case study

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Abstract- Telecommunication networks are a solution to accessing information in remote and marginalized areas. The availability of Internet has changed the way people share ideas and communicate, by eliminating limiting factors such as distance. The major problem for these deployed networks is that very few of the ones deployed in rural developing countries manage to stay operationally sustainable over long periods of time. The reason for this increased down-time is due to difficulty in fault diagnosis by the users, hardware failure and other environmental issues. In this paper we will discuss different cost effective ways and methods in which the availability (network uptime) and robustness for these networks can be improved and reinforced. We focus on highlighting different solutions which can be used to improve availability of telecommunication networks in rural communities. The network infrastructure has been deployed for the Siyakhula Living Lab (SLL) Information and Communication Technology for Development (ICTD) project undertaken within the Dwesa community.

Keywords – telecommunications, network availability, ICTD, Siyakhula Living Lab

I. INTRODUCTION

Research has shown that Information and Communication Technologies (ICTs), and particularly the new ICTs, contribute to improving the living standards of people in marginalized areas [1, 2, 3]. ICTs contribute to people's lives by helping them to stay well informed with information on subjects such as agriculture, education, and governance. As people become familiar with ICTs, they discover the opportunities that these tools can offer and express their needs on the basis of the estimated usefulness of these technologies [4, 5].

We have deployed a telecommunications network infrastructure allows the provision of different ICT services within the Dwesa community. There are different problems that are currently experienced on the SLL network. In this paper we analyse and discuss some of the common problems on the SLL network and also describe some solutions we have implemented to overcome the problems. We are working towards building a network that is resilient to failure.

As part of the solutions, in this paper we will discuss remote network and traffic monitoring systems that were deployed on the network. The deployed redundant links and backup systems have improved the availability of the network. The introduction of these various technologies and other social and organisational rules improved the network's reliability and performance and communication within the people in the community and their access to various services offered on the network.

II. CHARACTERISTICS OF RURAL AREAS

In any developing country, the characteristics and challenges faced by the people in rural areas are almost the same [6]. Some of the key characteristics are listed below as explained by Pitke [5, 6]:

- Lack of basic facilities such as water, proper roads and reliable electrical supply;
- Lack of technically skilled people;
- Environmental obstructions such as hills make the construction of telecommunications networks costly;
- More frequent failures to sufficiently protect equipment resulting in bad climatic conditions damaging it.

These characteristics sometimes make it difficult to provide telecommunications services under these areas.

III. OVERVIEW OF RURAL TELECOMMUNICATIONS

In South Africa, rural telecommunication networks have been deployed in schools since they are believed to be the central points of contacts where people are free to go and make use of the available resources [2]. This is also the case with the SLL network. In rural areas, schools are some of the places that are fairly secure and in other cases they are the only places with electricity. Despite these positive characteristics, rural schools also various issues that they should overcome before the introduction of ICTs [2]. Listed in the following sections are some of the problems that are faced by schools in rural areas.

A. Lack of computer hardware and software

Rural schools are in most cases remotely located and as a result the provision of computer hardware and software resources is limited since many organizations focus on urban schools [7]. As a result, students from these schools fail to get the required training in computer studies due to resource shortages [7, 8].

B. Lack of telephone facilities

Schools in the rural areas still rely on the old fashioned modes of communication like writing letters or word of mouth. This is a result of lack of telephone facilities [7, 9].

The introduction of telecommunication services is slowed down due to the lack of these facilities.

C. *Lack of technical training*

Rural communities have very few technically skilled individuals with experience in computer and internet use. As a result, there is no one to solve the problems on deployed sites when they occur. Most of the people with the knowledge on telecommunications leave the community for better areas creating a gap. We have experienced and noted most of these problems in the SLL network, and are focusing on improving it. [8].

IV. THE SIYAKHULA LIVING LAB

This research is done within the context of the SLL undertaken in Dwesa. The name Siyakhula means “we are growing together”. The University of Fort Hare (UFH) and Rhodes University (RU) run it jointly. Both universities are located in the Eastern Cape province of South Africa. The mission of the SLL is to develop and field-test the prototype of a multi-functional, distributed community communication platform for deployment in marginalized and semi-marginalized communities in South Africa. SLL aims to develop the marginalized community by equipping people in the area with the necessary technological skills to be able to support ICT applications and services deployed [7]. The SLL ICT infrastructure operates with positive participation from the local community members, researchers from the University of Fort Hare and Rhodes University, industry and government [10].

The existing ICT platform so far is deployed in four schools, namely, Mpume Junior Secondary School, Ngwane Junior Secondary School, Mtokwane Junior Secondary School and Nondobo Junior Secondary School [2]. The main components of the telecommunications network are a Very Small Aperture Terminal (VSAT) connection and Access Concentrator deployed at Mpume school and a Worldwide Interoperability for Microwave Access (WiMAX) Alvarion Breezemax Micro base station deployed at Ngwane school. Each of the four schools have computer laboratory that contains a server running Linux Terminal Server Project (LTSP), a web server, a database, a FreeBSD router and desktop clients [2, 10]. Additional equipment deployed in each of the four schools includes WiMAX Alvarion Breezemax Customer Premises Equipment (CPE) outdoor and indoor units and VoIP phone [2, 10]. We appreciate that the existing network is enabling communication between the schools. However, we aim to continuously improve the network services.

V.SIYAKHULA LIVING LAB NETWORK CHALLENGES

Few network systems that have been deployed in the rural developing regions have managed to run over long periods [11]. The reasons for these network failures differ from one area to another. In some cases network components fail as a result of poor electricity quality and bad weather conditions [3, 11]. There are damages experienced on the equipment which depends on the amount of AC transmitted to the equipment [3]. As a result of these factors, rural networks have lost valuable equipment like routers and servers in these areas. In most cases it may be very difficult to replace the damaged equipment due to shortage of funds. Another challenge that these networks face is finding solutions that are sustainable and cheap at all levels of the system [12]. In some cases the failure of a single point on the network has led to the whole network not working at all. These network problems end up developing from being simple to complicated since more damages are done when the local staff try to fix the problems without establishing the main cause.

A. *Difficulty in fault diagnosis*

Since the network users in rural areas are usually less technologically skilled, they sometimes misinterpret the faults that occur on the network. For example, a common description of faults by users of the Aravind network deployed in India is “the internet is down” [11]. In the SLL case, the network administrators have travelled to the network site only to realise that the crucial server at Mpume school was switched off, or that reason for network downtime was due to minor software problem which could be fixed if there was remote access to the network. A combination of lack of on site technically trained staff and unreliable systems can severely limit proper network monitoring and accurate diagnosis [10, 11]. The correct interpretation of network problems can save time and also prevent unnecessary travel. In other cases the network users do not fully understand the way the equipment is supposed to operate as a result it becomes even more difficult for them to notice or report when a problem occurs[13, 14]. On the SLL network, there are incidents when the users try to fix the problem locally when the actual root of the problem is not local. In our case, when VSAT link goes down the users have a tendency of changing local settings while trying to fix the problem, these attempts have created new problems such as mis-configuration.

B. *Fault Anticipation*

In the SLL case, visits to the SLL network sites are expensive, time consuming and require careful planning since the sites is located about 400 km from where the administrators are located. But the planning is not usually possible since the anticipation of fault is very difficult on these types of networks since there are limited remote monitoring capabilities on these networks. Hence urgent visits are made because when the equipment suddenly breaks or the network unexpectedly goes down [13]. In addition to the unplanned trips that are done when need arises, there are monthly trips that are done by students from the two universities for training purposes. If a problem arises during these training sessions, the students try and fix the problems. However, there are some general problems that are experienced by rural networks such as lack of proper maintenance, deliberate switching off of equipments by users and people not taking care of the equipment as their own [11]. These factors also affect the performance and availability of the deployed networks.

C. *Corrupt configurations*

The configurations on the crucial servers and routers sometimes get corrupt, resulting in the entire network failing to operate properly. Unfortunately, most of the corrupt devices have to be transported to the universities for reconfiguration.

D. *Lack of skill*

Due to lack of skill, damage to equipment on the network is sometimes done by local users who try to solve network problems that they are not well versed with.

E. *Lack of network traffic monitoring tools*

Since the network administrators are located far away from the network site there is need for them to monitor the amount of traffic and the health (ie which nodes, ports are up).

VI. SIYAKHULA LIVING LAB NETWORK SOLUTIONS

In order for us to conduct this work, we collected all recorded SLL network problems in order to try and come up with appropriate solutions. Most of the problems identified are popular in many rural networks. The people in the Dwesa area are cooperative, but sometimes lack the required skills to fully improve the network services. We came up with cost-effective solutions to improve the network availability for the Dwesa community. These solutions are listed below:

A. *Computer literacy training*

Students from the Departments of Computer Science and Education from the two universities offer training sessions to the users (in this case the users are the school teachers, learners and the people within the community). These users have received training in different courses such as the Siyakhula Computer Literacy Short Course (pre-ACE), Introduction to Computing and Basic Computer Concepts (open ICDL). This training has enabled the people within the society in solving the basic network problems and improved the interpretation and diagnosis of faults by the users before reporting them to the administrators.

B. *Redundant Internet link*

To improve the availability of connectivity to the Internet, we have introduced a GPRS connection using a Linksys router. It acts as a redundant link to the VSAT link so that the users remain connected even when the VSAT link is down. The Linksys router is directly connected to the indoor VSAT unit as shown in Figure 1.

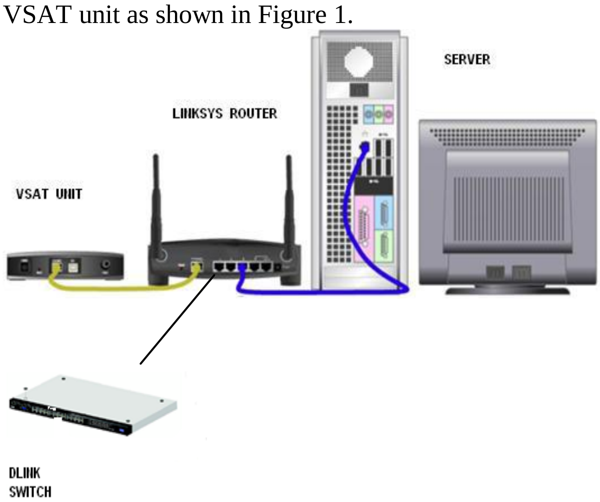

Figure 1: Connection of the Linksys router on the SLL network

C. *Network monitoring*

As a way to overcome most of the listed SLL network problems, we have deployed a monitoring system called Nagios. Figure 2 shows the architecture diagram of Nagios as deployed on our network.

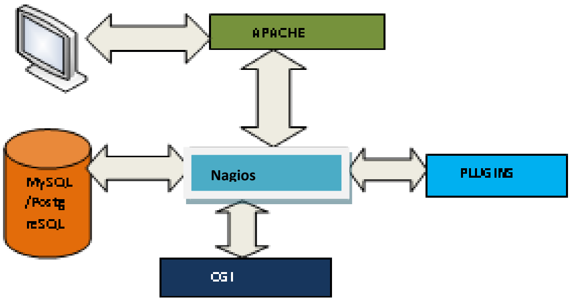

Figure 2: Internal architecture of Nagios [9]

Figure 2 indicates that Nagios requires Apache and MySQL database to be installed on the server machine for it to be able to run [15]. To make sure that Nagios catered for the specific needs of the Dwesa network, we changed some of the default commands. Below are some of the results obtained from Nagios to check the network's availability. From these results we see that different services that are monitored by Nagios and on average the network was up 97.622% of the time.

Service	% Time OK	% Time Warning	% Time Unknown	% Time Critical	% Time Undetermined
Current Load	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.378% (100.000%)	97.622%
Current Users	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.377% (100.000%)	97.623%
HTTP	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.375% (100.000%)	97.625%
PING	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.374% (100.000%)	97.626%
Root Partition	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.372% (100.000%)	97.628%
SSH	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.371% (100.000%)	97.629%
Swap Usage	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.370% (100.000%)	97.630%
Total Processes	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.368% (100.000%)	97.632%
Average	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	2.373% (100.000%)	97.627%

Figure 3: Services monitored on Nagios

D. *Connectivity between servers*

To continuously monitor the connectivity between the servers at Mpume and Ngwane, we deployed a PHP script at each of the servers, which we called *net-monitor*. To check for connectivity, a ping request is sent between the servers every two hours to check if there is still connection. If more than 50% of the packets are received on the requesting server, the conclusion is that the other server is on. If more than 50% of the packets are lost after sending the ping requests, the conclusion is that the other server is down, therefore a Wake on LAN (WOL) request is sent to boot the other server and another ping request is sent to ensure that the other server indeed went up. All the information collected from the connectivity test is stored in a log file. The *net-monitor* script works under the assumption that the routers and the servers on both schools are plugged onto power and onto the network and that other hardware component are also well connected. If that is not the case, then the people from the schools call each other to verify if all the equipment is switched on.

E. Backup System

To solve the problem of configurations being corrupted and community users having to wait for the administrators to take the devices to the universities, and then bring them back after reconfiguration, we have deployed a backup system called Simple Backup. This backup system keeps all the files in */etc,/root*. The backup files are sent to the administrator's email and also the same copy of the backup files is stored in /var/backup on the network device. We configured the backup system in such a way that it does a backup once every week because the network is small and configurations are not changed on regular intervals. A full backup of the whole system is done after every 14 days and backups older that 60 days are deleted from the /var/backup but they remain in the administrator's inbox. These updates are deleted after every 60 days to free computer disk space.

F. Traffic Monitoring

We deployed Cacti on the server at Mpume to get the data concerning the traffic and the usage of the network represented into graphs [11]. On the network we configured Cacti in such a way that the graphs can be viewed using a web browser [16]. We did not change a lot of the Cacti default settings, as they were similar to what we wanted. The servers at Mtokwane and Ngwane are also monitored by Cacti. An example of the results from Cacti is shown in Figure 4.

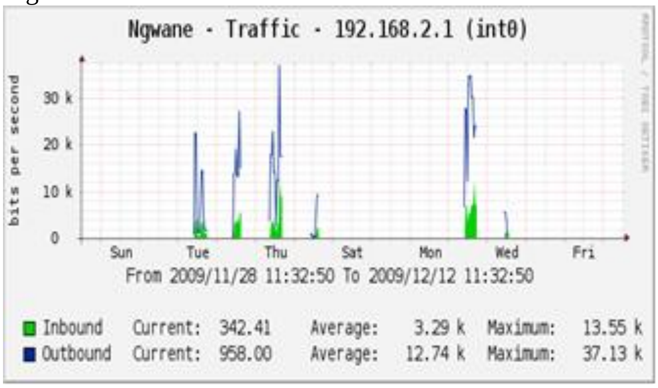

Figure 4 : Ngwane server internal interface (Int 0)

Figure 4 shows the traffic on the local area Ethernet interface (int0) of the server at Ngwane school. The Inbound LAN traffic at Ngwane is slightly above the stipulated average and less than its expected maximum. From the results we see that the current traffic is 342.41 kbps while the average is 3.39 kbps and the expected maximum is 13.55 Kbps. On the same interface the outbound traffic is higher than the inbound traffic as shown on the graph. The blank days (Monday, Friday, Saturday and Sunday) are the days when the computer lab was not in use and there was no traffic on that portion of the SLL network.

At the time this paper was written we had finished deployment and we are still getting feedback on the deployed systems so no comparison between the old systems and the newly deployed ones has been done.

VII. CONCLUSION

Provision of reliable network services is one of the objectives in this paper. Therefore in this paper, we have taken into consideration different factors, systems and strategies which could enable the reinforcement of rural telecommunication networks. We can conclude that after the deployment of the monitoring systems, network backup solutions and other hardware solutions, availability of the SLL network has improved. In terms of cost of running and maintaining the network, the monthly trips to the site have become more organised as they now follow a clear schedule due to the remote monitoring systems. The administrators now have a clear picture of the activities that occur on the network. Since the applications we have used are available freely Open Source Software such as Nagios and Cacti, this gives room for any future changes on the network since these applications can be modified to accommodate the changes. Additional features and applications to improve the network services are still possible. We expect the Dwesa community to have better services available, making use of the reliable network services provided in this research.

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