# NREN Network Security: A case study of Uganda Christian University ICT Infrastructure

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## Abstract

The long wait for high-speed access to the Internet is finally coming to an end. National Research and Education Networks (NRENs) are being connected to the rest of the world through high-speed fiber optic cables. This paper focuses on NREN security with Uganda Christian University (UCU) as a case study. It discusses how regional and national reseach and education networks will signifiantly lower bandwidth costs for the member institutions. It goes ahead to discuss the initial UCU ICT infrastructure, security practices and implementation, and then suggest recommendations based on lessons learnt and experiences.

**Key words:** NREN, 802.1x protocol, PacketFence, OpenLDAP and Network Security

## 1. Introduction

The number of devices connecting to the Internet has increased tremendously; Internet usage statistics show an overall increase in Internet penetration in the world, with a percentage penetration of 34.3% and an overall growth of 566.4% between 2000 and 2012 (Internet World Statistics, 2012). Developing countries are most certainly not being left out as they are also registering increased numbers of Internet users. All sectors have been affected positively by using Information and Communication Technologies (ICTs) to provide better services. The education sector has not been left out as in the past few years, National Research and Education Networks (NRENs) have been increasing in number and expanding in operation globally. In Africa, about 20 countries were reported to have either established or were in the process of establishing NRENs by 2009 (Boubakar, 2009). This increase was even more evident with the launching of the AfricaConnect Project (Tamsin & Maurice, 2012) which aims to establish high capacity Internet network for research and education in Southern and East Africa.

Research and Education Network of Uganda (RENU) – the Ugandan NREN - was born in 2006 to bring together public and private research and higher education institutions in Uganda whose core mission is to provide a better education and research environment geared towards the development of the country (UbuntuNet Alliance, n.d.; RENU, 2012). Research and Education Networks (RENs) in Uganda are in advanced stages of implementing their last mile connectivity to the National Backbone Infrastructure (NBI) of the government which will be the main



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infrastructure for RENU. This is to make sure that all RENs are ready for the AfricaConnect project implementation which is going to significantly lower the bandwidth costs to about a third of the current Ugandan market price.

According to a press release (Tasmin & Maurice, 2012), the Pan-European research and education network, and UbuntuNet Alliance, the regional research and education network for Southern and Eastern Africa, announced the launch of UbuntuNet Network, a high-speed Internet network connecting scientists and academics throughout Southern and Eastern Africa to peers in the region and to Europe, the first network of its kind in Africa. Mangheni (2012) estimates that bandwidth costs to NREN members in Uganda through the AfricaConnect Project will drop from the current US$630 per Mbps per month to about US$170 per Mbps per month. This means that if an NREN member uses 2Mbps per month, a semester payment for Internet will be able to drop from the current US$5,040 to about US$1,360. However, each member will need to meet their own last-mile fibre connection to the National Fibre backbone through which the NREN shall be accessing RENU services in future. Mangheni (2012) also adds that RENU is partnering with the National IT Authority for Uganda (NITA-U) with the aim of utilising NITA-U's national fibre backbone infrastructure to create a countrywide network.

If the AfricaConnect project is successful, typical issues of unlimited bandwidth will be history and the network bottlenecks will be transferred to end-users. In most cases, it is possible to embrace and appreciate the differences in technologies in terms of the network infrastructure because it is not very clear what each of them has to offer in terms of supporting applications. Varadharajan & Katsavos (1996) noted that, "the development of new applications such as networked multi-media, desktop video-conferencing and entertainment services accelerates the demand for broadband services." RENU initiative is going to increase the need for the interconnection of Local Area Networks (LANs) and providing high speed information transfer is becoming a strategic necessity for many institutions to support their growing number of workgroups based on backbone-type LANs and the need to conduct more research, innovation and easy access to information.

There is going to be a dramatic change in the nature of network traffic which will likely lead to interconnections at very high-speeds to Mbps and even Gbps. This of course comes with network security challenges both in design and application services and the NRENs need to implement mechanisms to counter those challenges.

Network security consists of provisions and policies adopted by a network administrator to prevent and monitor unauthorised access, misuse, modification, or denial of a computer network and network-accessible resources. Network security involves the authorisation of access to data in a network, which is controlled by the network administrator (Network Security, 2013).

Uganda Christian University (UCU) is a member of RENU and this paper looks at UCU's past and current network security practices for both wired and wireless networks and suggests a way forward for other NRENs.

## 2. Initial ICT Infrastructure at UCU

UCU became a University in 1997 and during that time, it had approximately 100 second hand



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computers with no Wireless Local Area Network (WLAN). About 60% of these computers were networked leaving 40% standalone and this network was in a few offices and student teaching computer laboratories. This small network was comprised of basic layer two switches and category 5e Ethernet cabling which was limited to 10/100Mbps. This network was not secured in anyway, meaning that anyone with physical access to the network would just connect and gain access to the network resources – this would be termed as a 'plug and play network' as indicated by Nsiko (2013).

Nsiko (2013) further stated that UCU network grew overtime and five years later, around 2002, the network expanded to over 300 networked computers for both students and staff. The expansion covered both wired and wireless, however, wireless was covering just 10% of the entire campus. Wired network was still unsecured, meaning everyone would just connect a device on the network with ease and access all the network resources. Wireless network was secured using Wired Equivalent Privacy (WEP) which is supported by virtually all 802.11a/b/g equipment . WEP uses a 40-bit key to encrypt data between the access point and client in such a case, the key must be entered on the Access Points (APs) as well as on each of the clients. For one to be given access to the WLAN, he/she would be required to physically visit the University Computing Services office and the Network Administrator would physically key in the wireless key for the user.

Currently the network has grown to approximately 13,000 both wired and wireless registered network devices/nodes, with wireless covering 60% of the campus that are centrally managed by PacketFence. A brief overview of the current registered and unregistered devices/nodes is shown in Figure 2.1.

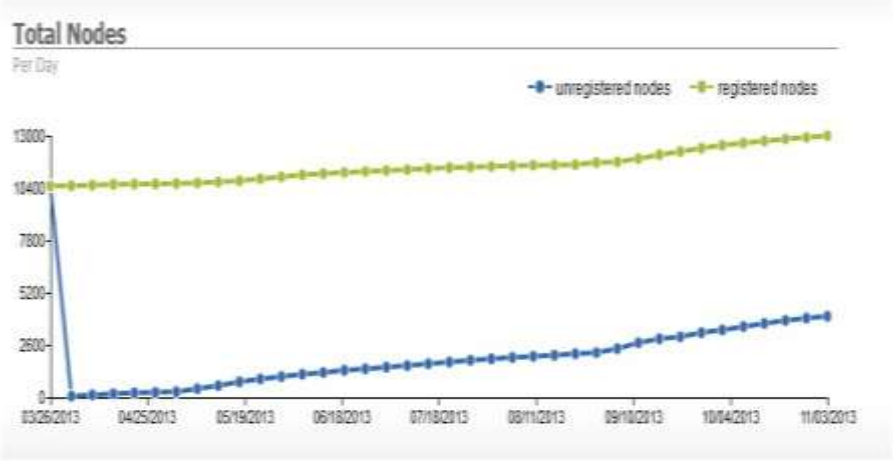


*Fig: 2.1 Uganda Christian Universities Registered and Unregisterd Network nodes*

*(Source; UCU PacketFence)*

## 2.1 The Problem

WEP provided an authentication mechanism while also adding some privacy to the network. According to Pietrosemoli et al (2011), WEP is not the strongest encryption available and this is



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because a WEP key is shared between all users. If the key is compromised, for example if a user tells his/her friend what the password is, or if an employee is let go, then changing the password can be prohibitively difficult, since all APs and client devices need to be changed. This was hard to contain and the key was easily circulated to the entire community and even non university students or staff would easily get access to the network as long as they had a student friend who would be willing to give them the key, sometimes even at a small fee. The ICT department was forced to rethink and come up with other solutions to the problem.

## 2.2 The solution

In order to have a secure network, UCU has been implementing different solutions which include Pfsense and PacketFence which are all based on Open Source software.

### 2.2.1 Scenario 1: WiFi Security using pfSense

With the rapid increase in the number of mobile/portable devices on the network, the University ICT Services department realised a need to enhance wireless security by introducing pfSense for students. Pfsense is a free , open source customized distribution of FreeBSD tailored for use as a firewall and router (PFSENSE, 2013). In addition to being a powerful, flexible firewalling and routing platform, it includes a long list of related features and a package system allowing further expandability without adding bloat and potential security vulnerabilities to the base distribution. Since the nature of the LAN was flat with no segmentation in place, it was very difficult if not impossible to have one central server for all the access points on the campus. In this case only one segment was secured using Pfsense.

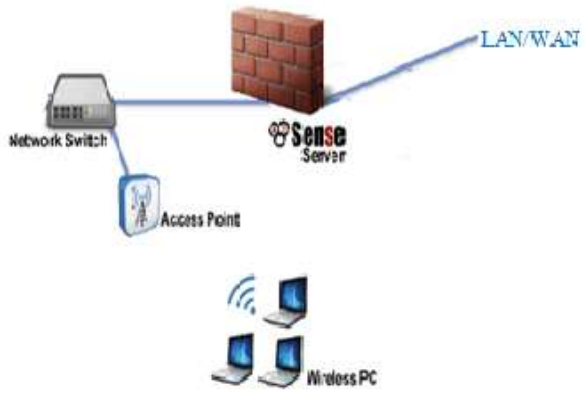


*Fig 2.2: Topology of PfSense installation on the LAN (Source: Developed by researchers)*

Pfsense box has two network interfaces with one pointing to the LAN and another one pointing to the WLAN serving the network where all the access points are installed. All users - in this case students and staff - who were intending to connect to the Wi-Fi network had to first visit University ICT Services (UIS) and have the physical addresses, that is, Media Access Control (MAC) addresses captured and entered into the captive portal of pfsense. However, captive portal authentication was being by-passed because there was no authentication system in place. In this case, access to the Wi-Fi network was based on the MAC address of the device and it was


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discovered that students had identified vulnerability in this setup and could fake MAC address and give themselves access to the network without necessary visiting UIS, meaning even non University students would gain access to the network and cause havoc. This setup was only for the wireless network, meaning that the wired network had no form of security.

Ou (2005) states that MAC filtering is like handing a security guard a piece of paper with a list of names. He gives an example of someone coming up to the door in order to gain entry; the security guard looks at the person's name tag and compares it to his list of names and determines whether to open the door or not. The problem with this kind of security is it is easy to manipulate. In comparison to a wireless LAN, in a very short time a sniffer/hacker can easily copy an authentic MAC address, paste it to their device and use it to gain access to the network. This is a very common security practice in many institutions despite the security risk.

### 2.2.2 Scenario 2: Current Network security using PacketFence

UCU currently uses PacketFence to provide security for both wired and wireless devices connecting on the network. PacketFence is a fully supported, trusted, Free and Open Source network access control (NAC) solution (PacketFence, 2013). PacketFence is rich in features like captive-portal for registration and remediation, centralised wired and wireless management, 802.1X support, layer-2 isolation of problematic devices. It can be used to effectively secure small networks and very big heterogeneous networks of all kind.

Initially UCU was using PacketFence without OpenLDAP basing only on MAC address filtering because of the nature of the network setup which was basically flat with no segmentation. This setup was completely weak in terms of security meaning that an attacker could easily sniff the network and capture valid MAC address which he/she would use to gain access as a legitimate user.

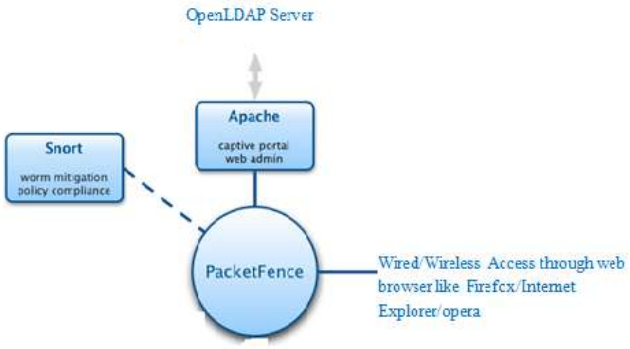


*Fig 2.3: PacketFence Implementation with OpenLAD*

PacketFence with OpenLDAP gives a stronger security mechanism which gives users access to the network using email addresses together with passwords as usernames and physical addresses of the device connecting to the network. In this case study, email addresses are issued to registered students and staff of the university. Devices are registered basing on the OpenLDAP authentication using the email addresses and passwords issued upon registration via the captive



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portal.

When a device tries to get access to the network, PacketFence firewall captures the details via MAC address and redirects it to captive portal firewall. Captive portal prompts for user name and password and acceptance of the policy agreement. If the user does not exists on the OpenLDAP server which is acting as an authentication server, he/she is denied access and if he/she is a valid user the request is sent to snort which also checks for violations on the device. Once the device is found free of violations and conforming to the policies defined in snort, it is then allowed to access the web page being requested and if the device has violations, they have to be cleared first before it can access the web page. Forms of violations include: viruses, peer-to-peer programs like BitComet, BitTorrent, and uTorrent.

## 3. Experiences from managing Campus Network

Managing a campus network is one of the most challenging tasks because new problems are encountered all the time. This is because being an academic institution, Computer Science or Information Technology students always want to try so many things taught in class on a live network and in the process, they end up creating a lot of problems to the Network Administrator. A typical example, creating network loops on a wired network brings the entire network down especially where basic layer two switches are used. Tracing such a problem is very hard on a huge network with over 600 data points, on a network which is flat with no segmentation and with no intelligent devices to detect and isolate the problem. Such problems can take a very long time before they are fixed and in many cases the entire network has to be brought down. Also administering a network with limited bandwidth is quite challenging where end-users expect high speeds while accessing the Internet.

## 4. Conclusions and Recommendations

RENs need to take network security seriously because it can make end users either frustrated or happy with services offered. NRENs need to build capacity of technical staff (like Network and Information Security experts) so that they are able to build and manage secure, reliable and robust networks. There is a bigger need to create awareness towards management so that they embrace NREN demands in building and securing the network.

Since NRENs are likely to out-compete commercial Internet Service Providers, it is important for them to safe guard their physical infrastructure against sabotage from competitors but at the same time secure from other forms of environmental hazards like road construction.

NREN members should consider building networks with smart/intelligent devices which can handle problems like network loops and network segmentation right from the access level. The use of Free and Open Source Software (FOSS) should be encouraged among NREN members because operational and support costs are lowered yet security is still achieved.

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## Biographies

**Perez Matsiko** currently works as a Technical Manager at Uganda Christian University in the University ICT Services Department; he also serves as a part-time lecturer in the Faculty of Science and Technology. He holds an Msc. in Data Communications from Makerere University and a Bsc. in Information Technology from Uganda Christian University. He has attended additional trainings in Microsoft, Networks, Fibre Optic design and installations, Linux System Administration. His research interests include Communication Systems and Network Security.

**Sarah Kiden** is passionate about ICT with a keen interest in Information Systems and Internet governance/ICT for Development. She holds an MSc in Information Systems from Uganda Martyrs University (Exchange student to St. Mary's University, Halifax – Canada), a BSc in Information Technology from Uganda Christian University and training in VSAT Engineering, Internet governance and IPv6. Sarah currently works as a Web & E-Learning Administrator at Uganda Christian University.


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