UbuntuNet-Connect 2015

Beyond Connectivity: the Road to NREN Maturity

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Margaret Ngwira and Tiwonge Msulira Banda
UbuntuNet Alliance Secretariat
P.O. Box 2550
Lilongwe, Malawi

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We would also like to acknowledge each and every author that saw it important to submit an abstract for selection. As we commend authors whose abstracts were selected for presentation, we would like to encouraged those whose abstracts were not selected to submit another abstract for UbuntuNet-Connect 2015 as we were only able to select a handful of abstracts due to limited number of presentation slots.

To all reviewers who accepted to review abstracts, we say: “Thank You.” Your prompt feedback and dedication ensured that the quality of accepted abstracts was exceptional.

Finally, we would also like to thank our sponsors who provided the financial and technical resources that made the conference and pre-conference events possible; XON, Network Startup Resource Center (NSRC), International Network for Availability of Scientific Publications (INASP), WIOCC, ICAAN, SIDA, The World Bank, the European Union (through the AfricaConnect project) INCM, MOVITEL and KAMBERY.

We thank you all: together we succeeded.
PART ONE:
FOREWORD

For the past 10 years, UbuntuNet Alliance has focused on providing connectivity to its NREN members and ensuring that the NRENs have access to sufficient bandwidth at affordable cost to enable collaboration among communities of practice. While it is an undeniable fact that a considerable number of NRENs within the region are yet to connect to the UbuntuNet network, the Alliance is satisfied with the progress being made by NRENs taking capacity from the Alliance.

As the Alliance is continuing to expand its connectivity within the region by connecting NRENs to its network under the AfricaConnect2 project, the Alliance believes that it is high time NRENs that have been taking services with the Alliance moved from being mere connectivity providers to their member institutions and started focusing on providing value adding services to NRENs: This is what was reflected in the UbuntuNet-Connect 2015 theme: “Beyond Connectivity: the Road to NREN Maturity”

The significance of NRENs transforming into service centres cannot be overemphasised: As private Internet service providers (ISP) continue to wage price wars with the Alliance, our NRENs need to show their member institutions that they do not exist simply to offer affordable bandwidth. Our NRENs need to offer their member institutions additional services like eduroam, edugain, iCloud services and data repositories. These value-adding services will make member institutions insensitive to lower bandwidth costs offered by private ISPs as these services can only be made available to them by a National Research and Education Network. In addition, these services have the potential of increasing the much-needed revenue for the financial autonomy of NREN members.

It was therefore encouraging to note that the global research and education networking community responded favourably to this ideology as evidenced by the nature of papers that were presented in Maputo, many of which focused on added-value services. As usual the response to the call for abstracts was overwhelming and it was unfortunate that other quality papers were not selected due to time and slot constraints.

As you will be reading, quoting and acknowledging these proceedings, UbuntuNet Alliance would like to express our gratitude to all those that submitted their papers, all paper presenters, companies and organisations that participated in the event either directly or indirectly: The Alliance owes you for making the conference a success.

We wish you good reading and looking forward to seeing you at UbuntuNet-Connect 2016, 3-4th November 2016, Kampala, Uganda.

Dr. Pascal Andoh Hoba

CEO, UbuntuNet Alliance
PART TWO:
PAPERS (a/z by 1st author)
Videoconferencing-as-a-Service for African NRENs

Robert BRISTOW¹, Peter MUIA², Geoff HOY¹, Meoli KASHORDA²

¹TENET, House Vincent, 10 Ebernezer Road, Wynberg, 7800, South Africa
Email: r.brustow@tenet.ac.za
²Kenya Education Network, P.O. Box 30244 - 00100, Nairobi, Kenya
Tel: + 254 732150500, Email: pmuia@kenet.or.ke

Abstract

This paper describes recent developments in the capability of Videoconferencing and the associated opportunities for a shared videoconferencing offering for African NRENs. The improvements in inter-African network capacity, taken with the maturing of new approaches to videoconferencing open an opportunity for African NRENs to take advantage of an investment that TENET has made in its videoconferencing platform.

TENET, the South African NREN operator, has established infrastructure to support multi-party high quality videoconferencing that brings together room-based conferencing (including H.323/SIP conferencing) with the capability to participate from desktop and laptop computers and from mobile devices. Due to the efficient software based characteristics of the chosen platform (Vidyo), participants are able to enjoy up to HD quality conferencing and content sharing in multi-party conferences.

The backend of the Vidyo infrastructure is available as software appliances to run as virtual machines (VMWare). This allows for a geographic distribution of the Vidyo infrastructure that enables maximum efficiency in the use of the SANReN network within South Africa.

Following an approach from KENET, the Kenyan NREN organisation, TENET has been able to further leverage the flexibility of the Vidyo platform to enable KENET to offer the capabilities of Vidyo to its Higher Education and Research communities in Kenya.

This paper and conference session will describe the details of this service and the key capabilities of the platform that allow for a distributed service. The paper and session will also outline the key economic, technological and organisational factors that make Videoconferencing-as-a-Service a compelling offering for African NRENs.

Keywords
Videoconferencing, cloud services, Vidyo, shared services

Introduction

This paper is a prospectus for a suggested shared service that will provide high quality videoconferencing capability for African NRENs at low cost. The suggested service is enabled by the opportunity to deploy videoconferencing infrastructure in a way that can be characterised as a Cloud type service (Armbrust et al. 2009), and builds on the investment that TENET, the South African NREN operator, has made to support videoconferencing in South Africa.
Videoconferencing has long been a technology that has promised much (Unruh 2000) and often failed to deliver on its promises (Single Malt Cloud, 2104). Technical reasons for this include cost of proprietary room systems and back-end infrastructure, complexity, the need for better bandwidth conditions than is necessarily available in African countries, and the limiting of videoconferencing to meeting and board-rooms due to the lack of affordable and capable desktop and mobile client software. Videoconferencing use in education is subject to some novel challenges that may need thorough analysis and development of strategies to overcome them, if the technology is not become yet another while elephant. (Lawson & Comber 2014)

Recent advances in videoconferencing technology have enabled products to emerge that overcome many of these historic obstacles to the widespread adoption of videoconferencing. In the case of TENET’s chosen platform, Vidyo (Vidyo, 2015), these advances include the wholly software nature of the stack (endpoints and infrastructure) intelligent matching of video and audio to the capabilities of endpoints in the meeting and scalability. This scalability refers not only to size of meeting but also to the availability of the software client on devices ranging from smartphones through desktop and laptop computers to full-blown telepresence type setups with multiple screens. Vidyo also allows existing videoconferencing endpoints using H.323 or SIP to join Vidyo meetings via a transcoding bridge. (Civanlar et al. 2009)

To enable collaboration and high quality meetings without the cost and trouble of travel for its customers in the universities and research council it supports, TENET invested in a Vidyo setup for South African higher education and research at the start of 2015. TENET put in place sufficient capacity to support these institutions in South Africa. Because Vidyo is a software-based system, TENET has been able to place infrastructure to support Vidyo meetings at key locations on the SANReN network in South Africa to ensure the most efficient use of network resources. Following discussions with KENET, the Kenyan NREN organisation, further infrastructure was placed in Nairobi to allow Kenyan universities and research organisations to use TENET’s pool of licensing capacity (KENET 2015).

This paper will further expand on the points made in this introduction and will outline an offer of a shared service that will enable collaboration across and within African NRENs. It will explore the key characteristics that make Vidyo a good choice for academic videoconferencing, and which make sharing the service relatively straightforward.

**Videoconferencing - the case for an NREN Service**

The question may well be asked as to why an NREN organisation should be in the business of running a videoconferencing service at all. Many NRENs offer or aspire to offer a videoconferencing service, some, based on traditional centrally provisioned MCU (Multiple Control Unit) model while others have been exploring routes beyond this type of service. TENET’s view is that while some of the better endowed universities in South Africa might well be able to provision the required infrastructure and support to meet their own needs for videoconferencing, many others would be challenged to make such provision, and that there was a real danger of fragmentation in the availability of solutions with consequent issues around interoperability.

One of the key challenges for South African higher education and research is to address the huge disparity between the very best institutions in the country and the rest. One key driver
for TENET’s establishment of a videoconferencing service was to provide a level playing field where academic discourse and collaboration both between the universities and research organisations and with external stakeholders could take place. TENET’s judgement was that there were considerable benefits in both financial and operational terms in the provision of a central managed service for videoconferencing rather than allowing a free-for-all where institutions might end up with islands of incompatible systems. These factors combined with significant cost savings accruing from the ability to share the service among the approximately 50 institutions that TENET supports, made the case for a central service.

**Why video and not web conferencing?**

TENET makes a clear distinction between web and videoconferencing. While there are many overlaps in terms of functionality, the affordances of the two approaches to collaboration have a number of distinctive characteristics (Stephenson & Downing 2012).

Web conferencing, which encompasses applications such as Adobe Connect\(^1\), Big Blue Button\(^2\), Blackboard Collaborate\(^3\) or Cisco WebEx\(^4\) are typically suited to one to many or instructional type scenarios, where the added functionally of being able to run quizzes and take feedback asynchronously is a determining factor. Typically web conferencing platforms default to a emphasis on the content being shared while the video and audio does not get the same emphasis. This can lead to less than optimal meeting experiences; with remote participants being displayed in any thumbnail views and audio feeds being bedevilled by poor quality and echo.

Videoconferencing (which includes Vidyo) emphasises the video and audio quality first and foremost, and is therefore more suitable for meetings involving conversation and the cut and thrust of argument and debate, and where it is useful to stretch beyond the desktop to room based conferencing setups, or a mix of room and personal device endpoints. Most videoconferencing platforms offer content sharing (this includes Vidyo) and in addition Vidyo has a “Presenter” mode which brings it closer to the web conferencing paradigm outlined above. Historically, videoconferencing was something confined to expensively equipped and inflexible boardroom settings, but the advent of the software based videoconferencing platforms like Vidyo means that it is now possible to provide client software to run on personal devices and a web client for guest use.

The point should be made at this point that some issues pertain to any type of video or web conferencing. For example, a poor quality camera, a backlit participant, a noisy room, bad lighting or lack of echo cancellation on the audio feed and poor meeting etiquette will degrade the quality of the virtual meeting, whatever technology is being deployed.

**TENET’s Offering for South African HE and Research**

Like many NRENs, TENET saw a couple of years ago that a videoconferencing service for South African higher education and research was something that was both needed and demanded by its customers. TENET explored the market, and for a while offered a Polycom

\(^2\) Big Blue Button - [http://bigbluebutton.org](http://bigbluebutton.org)
\(^3\) Blackboard Collaborate - [http://www.blackboard.com/online-collaborative-learning/](http://www.blackboard.com/online-collaborative-learning/)
\(^4\) Cisco WebEx - [http://www.webex.com](http://www.webex.com)
hosted VMR (Virtual Meeting Room) service to interested parties. This service saw patchy take up - a couple of institutions made use of it, but most failed to find use cases that might justify the cost of the service. Some of the characteristics of the hosted VMR service that made it less than useful were that the VMRs were fixed and allocated - so institution X had a five port VMR, but those ports could not be shared with institution Y or Z when X did not need them. As these were Polycom VMRs, and other H.323/SIP endpoints could join, there was no cost effective desktop or mobile client software that people could use if an H.323/SIP equipped meeting room was not available.

TENET terminated that service in 2014 and looked for an alternative. From consultation with the videoconferencing support teams in the institutions, TENET knew that it needed a service that was scalable, would work with existing H.323/SIP installations, would add support for desktop and mobile connections, would offer easy guest access and that would allow for streaming and recording. A further essential characteristic was that the service needed to be hosted within or connected directly to the SANReN network and have good in-country support from suppliers or developers.

TENET selected Vidyo as a product that best matched these criteria. Vidyo is one of the new breed of videoconferencing platforms that are appearing as alternatives to the traditional H.323/SIP offerings that have dominated the market up to now (Karcher 2013). Vidyo has a number of key characteristics that make it very suitable as the platform through which an NREN can offer a videoconferencing service. These include:

- **Use of the SVC extension to the H.264 standard**: Vidyo uses SVC to transmit video streams between participants. Vidyo’s own way of implementing SVC means that the video image stays robust even in fluctuating or less than ideal network conditions;
- **Entirely software based stack**: Vidyo’s entire offering is available as software that runs on non-proprietary hardware and OSs. This includes the room system capability, the desktop and mobile clients and the backend infrastructure;
- **No transcoding or re-encoding needed**: Vidyo calls are intelligently managed by the VidyoRouter infrastructure component that does no transcoding; it simply routes traffic in the most efficient manner possible. The means that a single hardware VidyoRouter or its virtualised equivalent can handle up to 100 concurrent connections. Vidyo uses the processing power of the endpoints to do the coding and decoding work;
- **Very high quality video**: On suitable hardware Vidyo will transmit at up to 1080p and can display up to 5K images. This makes Vidyo a good option for medical or engineering applications, as well as allowing for the best possible meeting experience for more routine activities;
- **High quality audio**: Vidyo has its own built in software echo-cancellation and will intelligently use hardware echo-cancellation if the audio device in use has that available;
- **Very low latency**: Unlike conventional MCU based system, Vidyo introduces very little latency into the meeting experience, and manages the lip syncing so that the audio stays in sync with the video;
- **Allowing existing H.323/SIP Endpoints to participate**: Vidyo offers a VidyoGateway device (as a virtual machine if required) that allows organisations’ exiting investments in Polycom, LifeSize or Cisco to join Vidyo meetings. The
VidyoGateway can also be used as a virtualised MCU for pure H.323/SIP calls is required;

- **Web client for guest users**: Guest users are sent a web link that once clicked, downloads a small plug-in to the browser (no restart needed) which then joins the meeting. Registered users can invite potentially unlimited guests to their meetings. From early next year the requirement to download a plug-in will be replaced by support for WebRTC;

- **High quality content sharing**: In a Vidyo meeting all participants can share content from any open window on their computer or their entire desktop. Each participant can choose which share to view (or none);

- **Distributed deployment options**: Vidyo supports a robust but flexible distribution of infrastructure that allows organisations to establish VidyoRouters and VidyoGateways in locations that allow users’ traffic to make efficient use of the available network capacity. This distributed infrastructure can draw on a common pool of licensing and support;

- **Multiple organisations can share same installation**: Vidyo allows the creation of multiple “Tenants” on the same installation. This allows TENET to offer each institution its own VidyoPortal and ability to connect that to institutional authentication systems;

- **Flexible Cloud style licensing options**: Vidyo’s “Hosted Lines” licensing model is based on a licence of a number of concurrent connections to the service. This pool of concurrency can be shared between multiple users, and between multiple tenants;

- **Recording, Replay and Streaming**: The VidyoReplay (available as a virtualised appliance) allows for multiple concurrent recordings, streaming and replay or downloading of recordings at a later date.

This graphic illustrates the parts of the Vidyo system. The way in which TENET has put these components together will be described below.

![Vidyo components](image)

Figure: 1 Components of the Vidyo suite of the products (Source: Vidyo)

In researching the market for videoconferencing systems, it was discovered that Vidyo is the system in use by the European Organisation for Nuclear Research (CERN) and by a number of other NRENs around the world, as well as the other big science project represented in South Africa: The Square Kilometre Array (SKA). The example of CERN was of particular
interest as the installation there accommodates 40,000 users, at times up to nearly 1,000 concurrent users and regular meetings of 20, 30 or 40 participants (CERN 2015). This showed that Vidyo was a platform that could easily scale to accommodate the foreseeable needs of South African higher education and research.

Another notable user in Africa is AIMS (the African Institute for Mathematical Studies) based in Muizenberg in the Western Cape, South Africa, but with regional centres in many other African countries. AIMS uses TENET Vidyo infrastructure to link with universities in South Africa and also with its regional centres, as well as funders and partners in Canada and Germany.

In addition to these high profile use cases for Vidyo, it was noted that a number of NRENs in Europe are rolling out videoconferencing services based on Vidyo, the most mature one of which is Vscene (Jisc 2015), which is offered by the UK NREN organisation, Jisc, and is used in a shared service arrangement by the Irish NREN, HEAnet (HEAnet 2015). There are also indications that CERN will be looking to offer Vidyo as a service to NRENs who are part of Géant\(^5\) in the near future.

**TENET’s Vidyo Infrastructure**

To realise the ambition to provide top class collaboration opportunities for its users, TENET has set up a Vidyo infrastructure with nodes in Cape Town, Johannesburg and Durban, these being the three major centres on the SANReN network (TENET, 2015). There is a VidyoPortal that looks after user accounts and system management tasks, and there are three VidyoRouters each capable of handling up to 100 concurrent connections as well as a cluster of VidyoGateways with a combined capacity of 12 concurrent up-to HD quality for connections from H.323/SIP endpoints. There are also five telephone lines running over SIP into the VidyoGateway cluster that allow participants to join by voice only. All these components run as virtual machines under VMWare. Users in different parts of the country are assigned different Location Tags that determine which VidyoRouter they access. This ensures the shortest network path to the Vidyo infrastructure from the endpoints and saves on network bandwidth between the parts of the infrastructure.

The SKA (Square Kilometre Array) South Africa\(^6\) had a considerable Polycom estate already in place, but were looking for ways to make that set up more flexible, They make use of the TENET VidyoPortal and VidyoRouter but have deployed their own VidyoGateway internally to allow them to have guaranteed access to the H.323/SIP bridging capacity that they need. This is an example of a hybrid cloud arrangement, as the SKA can also draw the pool of H.323/SIP bridging in the wider TENET setup.

In addition to the deployment outlined above, TENET has worked with KENET, the Kenyan NREN organisation to setup a VidyoRouter and VidyoGateway on KENET’s VM platform in Nairobi. This has enabled Kenyan users to make use of the Vidyo infrastructure (including TENET’s pool of licences) while keeping the video and audio traffic between endpoints within Kenya when speaking to other sites across the country.

\(^5\) Géant - [http://www.geant.org](http://www.geant.org)

\(^6\) SKA South Africa - [http://www.ska.ac.za](http://www.ska.ac.za)
These two examples demonstrate the way that the Vidyo infrastructure can be designed to enable best use of bandwidth and a hybrid type environment mixing external with internal capacity.

Figure: 2 This graphic shows the schematic for TENET’s Vidyo platform:

The UbuntuNet Alliance and wider African NREN Connectivity Opportunity

With improvements in intra-African connectivity, NRENs in Africa are now able to start to look beyond their own networks and identify and exploit collaboration opportunities, as is illustrated by one of the major themes of this conference. The promise of AfricaConnect2 (AfricaConnect2 2015) is that the opportunities will increase for African NRENs to realise the benefit of Cloud and other shared service initiatives such as the one being proposed in this paper.

The offer

Given the existence of the TENET Vidyo infrastructure and the ability of that infrastructure to scale and support a distributed cloud based model of provisioning, along with the improvements in intra-African network links, and the requirements that universities and researchers have for high quality video and audio collaboration tools, TENET would like to offer other African NRENs the opportunity to bring into play capabilities for videoconferencing in a cost-effective manner.
One possible model is that TENET will procure and manage the core Vidyo infrastructure and will supply support and training. NRENs wishing to benefit from this service will provide a suitable VM platform to enable provision of a VidyoRouter and, if needed, a VidyoGateway local to their network. TENET will connect these infrastructure components into its Vidyo “cloud” and will configure this set up to ensure that traffic from to and from users in a particular country stays in that country, while enabling collaboration across borders when that is required. Due to the flexible way in which Vidyo can be deployed, there is scope to add further components to the local setup, such as additional VidyoRouters, Gateways and even VidyoRecorders/Replays. Further elaborations of this core model can be made in due course as the service develops.

Benefits
For African NRENs the benefits of taking up this offer is that it will enable a cost effective improvement in the ability of their users to collaborate using high quality video, audio and content sharing, while having very few management or technical overheads beyond the provision and maintenance of a small VMWare setup.

The benefits for the users of the system will come from the access to high quality collaboration via video and the ability reach out beyond the walls of their institution to gain access to resources and expertise that is not available locally. To given an example from South African experience, the mathematics and statistics community in South Africa is exploring the use of TENET’s Vidyo service to enable better collaboration between mathematics and statistics faculty across South Africa, which will include initially, opportunities for improving access to supervisors for students at Masters and Doctoral level and in time to develop a networked Masters programme with teaching being delivered from departments across the country and also from overseas.

Next steps
As was stated in the introduction to this paper, this is really a prospectus. TENET is very open to further discussions with interested parties to design a robust business model for a shared service for videoconferencing. Costs of bringing high quality videoconferencing to universities and research organisations across the continent are very modest, especially when placed against the maintenance costs of existing H.323 endpoints and MCUs.
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Biographies

Rob Bristow is currently working as a Visiting NREN Fellow at TENET (the South African NREN Operator). He is on a secondment from Jisc, the UK NREN organisation. He has an extensive background in the deployment and support of various sorts of videoconferencing platforms and has been responsible for research that explored the financial and environmental benefits of videoconferencing in for higher education and research. He currently lives in Cape Town, and is enjoying exploring as much of Africa as possible before his return to the United Kingdom at the end of next year.

Geoff Hoy qualified as a zoologist and initially lectured at the University of Cape Town (UCT), before changing careers and qualifying in electronics and working in electronics for a number of years. This naturally lead to an interest in computing and he then managed some of the networks before managing UCT’s. In 1998 he moved to the UCT Libraries as deputy director so as to facilitate the libraries implementation of move to electronic resources. In 2006 he moved to TENET (Tertiary Education and Research Network of South Africa) where he is responsible for service management (acting), project management, & capacity development. He is now involved in the Rural Campus Connectivity Project Phase II, connecting rural campuses to the SANREN Network. He is excited and passionate at the potential that video conferencing has for teaching and learning and the time that can be saved instead of traveling.
Achieving Smart Resource Management for Better Disaster Management using Space-based Technology in Lowershire Basin, Malawi

Donnex CHILONGA

Mzuzu University, P/Bag 201, Luwinga, Mzuzu 2, Malawi
Tel: +265 882756490/+265 99937102, Email: donnexc@gmail.com

Abstract

Advancements in new geo-spatial technologies across the globe are seen as a way to advance the decision-making process of first responders before and after a disaster. Unstructured disaster information and an infrastructure for accurate disaster information may be accessed and retrieved successfully through present new and important tools. Such tools could help improve the performance of disaster prediction in any country across the world. This paper illustrates a method based on incorporation of space and terrestrial technologies that aims at providing vital information to first responders for smart management of floods in Lowershire Basin, Malawi.

Keywords: Lower Shire Basin, Mtayamoyo, Geo-spatial technologies, Global Positioning System (GPS), Geographic information system (GIS), Flood control, Malawi

Introduction

Natural hazards affect humans’ life and health at different scales in time and space, causing a dramatic impact on the sustainability of society, especially those that are vulnerable because of their geographic location or poverty. Natural disasters are a characteristic of life of the first decade of the twenty-first century (Stallo, Ruggieri, Cacucci, & Dominici, 2013). Events such as droughts, floods, earthquakes and cyclones have rendered human beings destitute. In January 2015, Malawi was struck by floods. Preliminary reports indicated that the floods left at least 174,000 people displaced, with 62 deaths and 153 people missing. The situation prompted the President of the Republic of Malawi to declare a State of Emergency on 13th January in 15 districts (out of the 28) of Nsanje, Chikwawa, Phalombe, Zomba, Blantyre, Chiradzulu, Thyolo, Mulanje, Balaka, Machinga, Mangochi, Ntcheu, Salima, Rumphi and Karonga (Weekend Nation Newspaper, 7th October 2015).
Considering the degree of damage highlighted above, and that which is to come in the subsequent rainy seasons, it is therefore necessary to study and develop very efficient tools in order to forecast these natural disasters, which can cause economic and social damage anywhere in the world. Presently, development initiatives by the United Nations, with the support of the European Community are underway for the prediction and early warning of such events (Buscema & Ruggieri 2011). To provide an early warning of an impending flood and improve the first response calls for the provision of proper and prompt information to first responders.

During such disastrous events and in anticipation of the same, Stallo et al, (2013) emphasize that when developing tools for forecasting natural disasters, floods in particular, one needs to consider the kind of information that must be made available to first responders to improve their response. At the same time, one needs to think of the mechanism of how the information can be distributed in an efficient way?

In addressing the first consideration (i.e. of the kind of information to be provided) Lunduka, Phiri, Kambani & Boyer (2010), in their final research report on *Malawi Disaster Risk Reduction and Climate Adaptation for CORDAID*, identified the following to be the needed information that must be available to civil protection committees vis-à-vis first responders: Information about people, goods, infrastructure i.e. roads and buildings and their likelihood to collapse; about relief centres where disaster victims can go for safety; about how relatives of victims can be contacted; updated disaster and safety maps specifying vulnerability and new risk levels and the likelihood of occurrence of another catastrophe. Such information is vital as it helps rescue and technical assistant teams to be more efficient and timely in their relief attempts. The information may be made available through satellites, sensors and radio frequency identification (RFID) technology (Stallo et al, 2013).

The information described above can thus be collected and distributed using a Swarm network operated between Navigation Communication (NavCom) and Earth Observation (EO). This system, if properly customised, can be used in various kinds of disasters because it adopts a modular approach (Muraleedharan & Osadciw, 2000).
Therefore, this paper describes Swarm intelligence, an integrated system that aims at providing information to civil protection workers and first responders for early warning of a disaster and immediately after it. Such information will, among others:

a. Enhance local understanding of natural disaster processes;

b. Assist first responders in preparing for such and related events i.e. Early warning instruments for preparedness; Emergency recovery and relief;


d. Help in the development of a real-time, web-based geographic information system (GIS) database platform which can be easily accessed for monitoring and risk mapping.

1.1. **Swarm intelligence and its Uniqueness**

Swarm intelligence is the joint behaviour of a group of social insects, for example ants, birds, where the agents (insects) communicate in the system either directly or indirectly using a distributed problem solving approach. This approach supports an optimised routing design, avoids stagnation, and prevents centralization of the network nodes. Since the routing in wireless network is never static, this intelligent sensor approach provides a solution to dynamic and distributed optimisation problems, making the network to be robust, flexible, decentralized, coherent and self organized (Kennedy & Eberhart 2001).

Swarm agents (ant agents) are randomly placed over the network and consist of three features; Pheromone Level, Transition Probability and the Tabu-Lists. Real life ants deposit a chemical substance called pheromone, which serves as a trail for the other ants to follow. The ant system mimics this pheromone deposition by laying pheromones depending on both energy level at the sensor node and the distance among the different pheromone levels {one node to another} (Muraleedharan & Osadciw, 2000).

Thus, Swarm intelligence system is unique and ideal in providing information to civil protection and first responders for early warning of a disaster and immediately after it because:

1. It distributes data intelligently and innovatively through a NavCom and EO integrated system to activate a swarm network (Heinzelman, Kulik, & Balakrishnan, 1999);

2. It smartly identifies the useful data to be gathered, recorded and distributed. This data can be real-time and/or survey-based. Real-time data can be localized or globalised data. Both local and global data can be obtained from the earth’s ground surface (i.e. through sensors, RFID technology smartphone, local and geological data); and from the sky (i.e. through global positioning system (GPS) and synthetic aperture radar [SAR], local and global meteorological data) (Stallo et al, 2013). Survey based data can be obtained from interviews of the victims of the disaster, geological survey, historical survey and data collected from call centres, from first responders and from the general community (Stallo et al, 2013).

3. It is a contemporary and advanced NavCom systems design for emergency rescue applications (Kennedy & Eberhart 2001). It involves the utilization of space systems and terrestrial enhanced wireless/mobile radio systems for the management of first phases of a disaster. The use of extremely high frequencies (EHF) [30–300 GHz], for example W band frequencies [75–110 GHz] makes swarm intelligence system idyllic for developing a highly secured applications such as Public Safety and Disaster
Recovery (PSDR). It further gives assurance of reliable communications with minimal susceptibility to jamming, and the ability to achieve smaller, secure, high bit-rate beams by using small-sized antennas (Stallo et al. 2010).

2. Space-Based technologies and data collection

It is necessary to emphasize that one of the most important and controversial uses of satellites today is that of monitoring the Earth's environment and the processes that take place on it. The ability to forecast weather, climate, and natural hazards, environmental monitoring and ecological issues depends critically on these satellite-based observations. Based on this data it is possible to gather satellite images frequently enough to create the model of the changing planet, improving the understanding of Earth's dynamic processes and helping society to manage limited resources and environmental challenges. Satellites that observe the Earth to collect scientific data are usually referred to as "Earth observation satellites." Sometimes the interpretation of their data has been controversial because the interpretation is difficult (Rustamov, Salahova, Zeynalova & Hasanova, 2012).

Recent studies on the use of space-based technologies have established that the measurements of earth surface changes can better be achieved through the use of GNSS networks that are aided by augmentation systems, such as the European Geostationary Navigation Overlay System (EGNOS) and EO. The use of these techniques, combined with other disciplines, can generate reliable hazard maps and define disaster preparation zones (Barbera, Stallo, Savarese, Ruggieri, Cacucci, & Fedi, 2010). Further, earth surface deformations such as changes in the properties of the crust (density, electrical resistivity, changes in groundwater levels, and other geochemical precursors) can also be detected by EO. EO data can be derived from GNSS observations, high-resolution satellite images, SAR, and photogrammetry (Dominici et al. 2011).

GNSS data can thus be obtained from permanent stations (PS) scattered within the area of interest. Each station is equipped with a receiver, a geodetic antenna and a local acquisition system guided by specific software for storage of all positioning data and continuous compilation of all satellite signals and the recording of their code and phase over time. This information is broadcast in real time by the transmission and receiver hardware (H/W) of the permanent station. The data recorded can be accessed by authorized users during the last hours for the entire area covered by the service. Combined with high-resolution satellite images (i.e. both multi-spectral and panchromatic), this information can therefore be used during both the pre- and post-emergency periods.

2.1. Data Collection and Information exchange

Data collection and the exchange of information are easily performed through the development of swarm network architectures, wireless networks, and advanced sensors (Engelbrecht 2005). For an improved decision quality and for a reduction in answer time, the information needs to be spread widely throughout the area of interest. The use of the “swarm intelligence” means using autonomous individuals who are able to cooperate with others and adapt to environmental variations. In the context of a disaster such as floods, a swarm network can help during the prediction phase and initial rescue period.

Muraleedharan & Osadciw (2000) identified three desirable functional properties of the system-level procedure of a swarm sensor network, which include:
• robustness: ability to operate even during disturbances from the environment or the malfunction of its individuals. The loss of an individual is immediately compensated for by another one. After all, the coordination process is decentralized.
• flexibility: ability to perform tasks of different natures.
• scalability: ability to work under a wide range of group sizes and support a large number of elements without considerably impacting the performance.

Coordination mechanisms are also considered here, two of which are: self-organization and stigmergy. The former is crucial where real systems are made up of real nodes (i.e., robots, sensors), because it is the basic standard behind the autonomous behavior of the agents. Hence, a swarm system does not need a central station driving the whole system because it is able to configure itself. Self-organization therefore is the capability of a system to change its organization in response to environmental changes without explicit external commands. The latter, in real applications, is a behavioural property of the agent/node to modify the environment in which it is moving, in order to reach a specific goal (Kennedy & Eberhart 2001).

These coordination mechanisms are important because they simplify the organization of the swarm toward the final formation. As such, agents are aware in real-time of their position and can move according to it (Hadin & Mohamed 2006). This important role is played by the positioning accuracy and precision of GNSS.

To this far, two projects have been developed by the URTV:
   i. Software-to-Hardware Pen-Drive (SoHa-Pen) project: where GPS receiver is associated with each agent for specific performance during the phases of risk (Stallo et al. 2010; Barbera et al. 2010).
   ii. Satellite Compass project: based on the use of the satellite compass for very accurate monitoring of strategic buildings or infrastructures.

3. Adaptive Information System for Prevention and First Response (AISPR)
AISPR is an independent and all-encompassing network of varied multi-sensor nodes that provides an infrastructure that is able to route the proper information to a diversified people in the proper places and time during a disaster, provided that the users are enabled and have proper authorization at that particular moment. The major aim is to assist the operator in making the best decision. Such distribution ensures reliability, availability, promptness, and security (Kennedy & Eberhart 2001).
The density and adaptive ability of the nodes, coupled with the serverless architecture, make the AISPR system intrinsically robust and able to function even with some malfunctioning nodes. Each node is fitted with sensors that give disaster and structural information of the place where it is deployed. The information that is given is time stamped and georeferenced to give a detailed and updated picture of the territory.

Apart from being used as a database for collecting data on events that occur in a building before an event, AISPR may also act as a provisional communication network where data among different nodes can be exchanged.

Data processing can thus be done using the following main tools:

- artificial adaptive systems, such as artificial neural networks. These manage extremely complex information so as to predict disasters and to create maps of disaster risk factors;
- data collection and exchange of information.

Upon completion of data processing, a coordination service needs to be provided by institutional organizations so that all these great amounts of data are used in a proper way to guarantee effective coordination and synergy among players such as civil protection, police, and rescuers etc. Via an online portal, information related to floods can be collected and disseminated.

3.1. System Architecture

The system is based on a three-tier architecture consisting of the database tier, the portal tier, and the service tier.

The system architecture consists of:

- an online portal;
- a system database comprising of semantic analysis tools and an artificial adaptive system for data analysis;
- the sensor network;
- the GNSS and SAR networks;
- GIS/management information system (MIS) subsystems.

Online forums are used to collect both structured and unstructured heterogeneous data coming from different sources (for example, sensors, GPS, satellite measurements, folk information, interviews, etc.). Structured data are directly stored in the database, whereas unstructured data are processed using a semantic analysis tool and structured in order to be stored. Scientific measurements conducted in the area of interest will also be stored in the database. Online forum subscribers will be able to access the database in order to find useful
information. The database will be supported by an artificial adaptive system for data analysis that could be managed by selected users (Stallo et al, 2013).

3.2. Exemplifying the usability of the architecture in Lwershire Basin
To illustrate the capabilities of the architecture for improving first-response activities, let us analyze a typical flood disaster scenario at Mtayamoyo bridge on Mtayamoyo River in Nsanje district, Malawi.

3.2.1 Illustration stage 1
Immediately after the floods on Mtayamoyo River, a sizeable amount of new data, coming from the affected area, is made available and stored in the database:
- “on-ground” sensor data;
- airborne or satellite sensor data (Note that this information is not current but is usually a few hours old);
- direct information from people affected by the event made available through online forum, phone calls or text messages to civil protection;
- information from the civil protection workers in the flooded area.

3.2.1 Illustration stage 2
Think of the collapse of Mtayamoyo bridge on Mtayamoyo River in Nsanje district. This event can be recorded by sensors deployed at various strategic positions around the bridge and by people living in the surrounding area; hence, the following data should be available:
- A direct call with a message such as, “Mtayamoyo bridge on Mtayamoyo River, at Bangula Trading Centre, is swept by water.” Using semantic analysis, the following information about the bridge can be stored:
  - Geographic coordinate position of the bridge (i.e. Longitude and Latitude)
  - Possible road obstruction
  - Possible presence of victims
  - Possible presence of displaced people around the bridge
  - Possible damage to property of displaced people
  - Estimate of volume of water recorded by a sensor near the swept bridge

Such data could be directly forwarded to civil protection workers in the area and be used to improve first-response activities. At the same time, the data coming from the civil protection operators can be used to update the data stored into the database together with data coming from airborne/satellite sensors.
All of this updated information is of utmost importance not only in the coordination of disaster response activity but also in enhancement of rebuilding and restoring activities.
4. Conclusion

It is established in this paper that advancements in new geo-spatial technologies across the globe is a means to advance the decision-making process of first responders during a disaster. Such tools could help improve the performance of disaster prediction tools developed in any country in the world. This paper has illustrated a system based on incorporation of space and terrestrial technologies that aims at providing vital information to first responders for smart management of disasters. By creating a database that can be used to gather and exchange information about disasters (drought or flooding, in particular) coupled with previous experiences of first responders, people involved in disasters, and scientists studying disaster processes, will allow for better preparedness and more effective responses to the future disasters, thus improving the capability to restore normal activity after a crisis situation.

References


**Biography**

Donnex Chilonga is a research scientist cum geographer with specialty in the utilization of space-based technology in solving current social problems. He has been teaching at University level since 2012. Throughout his 4-year span Donnex has built a reputation for developing space-based scientific models tailored for disaster management. Together with his colleagues in the Geography and Earth Science department of Mzuzu University, Donnex is a lead on building a model for communication for first responders in times of flooding in Malawi. Donnex’ academic background includes a PGD in Remote Sensing and GIS and BA (Geography) obtained from African Regional Centre for Space Science and Technology Education, Obafemi Awolowo University and Mzuzu University respectively. His interest in environmental protection for equitable use saw Donnex obtaining a Diploma in Law from the University of Malawi’s Chancellor College.
Question Banks: A tool for improving Higher Education Assessment across National Resource Networks: The Polytechnic of Malawi case study

Chifundo CHILIVUMBO

The Polytechnic, University of Malawi. P Bag 1, Blantyre. Malawi
Tel: +265 99 1303868, Email: Chifundo.chilivumbo@gmail.com

Abstract

Question Banks are used to increase the access to quality material for assessing the students in institutions of higher learning. A good question bank which is in line with the learning orientated assessment framework, should facilitate the, learning orientated assessment tasks, developing evaluate expertise and aid in student engagement with some feedback. This paper seeks to create a solution that will allow for these properties to be streamlined by an information solution for higher institutions to be delivered over National resource networks, with one of the University of Malawi’s constituent colleges, the Polytechnic as a case study. This paper documents the work done with the Department of Mathematics and Statistics and Language and Communication in the Faculties of Applied Sciences and Education and Media Studies respectively. Information about the assessment creation and assessment artifact storage was gathered from these two departments through the study of existent literature, observation of processes and a self-administered questionnaire given to participants from the two departments. The first version of the software was created with work being done to improve the system to ensure it’s efficiently aids the assessment process. Although the current process is paper based the system tracks the process using an electronic solution with the aim to allow for an aid to creation and research of questions and possibly in the future for electronic delivery of assessments. The system also takes into account the issue of interoperability of the new system with the Universities existing systems that support Virtual Leaning and Student Information Management.

Keywords: Question-bank, Assessment-Moderation, Higher Education, Assessment Artifacts, Moderation, E-assessment.
1.0 Introduction

The University of Malawi’s constituent college, The Polytechnic, has put in place several Information Communication Technology (ICT) Systems to enhance and support its activities. It has a student management system to aid in the tracking of student data including fees, assessment results, registration statuses and student bio-data information to name a few. It also employs the use of Information Technology in the extension of services such as those offered by the Library and the teaching staff. Online library sources are offered to students both on and off campus. Virtual Learning Environment platforms are used to extend the teaching staffs’ class content to students online.

These systems as seen above have been employed in many areas of the University core activities. However, one area that is lacking in this intervention is that of assessment creation and assessment artifact storage. This paper seeks to address this deficit by attempting to introduce an Information System solution to manage and automate the assessment creation process.

Similar studies such as that of the Universities of Southampton, creating large-scale test banks found that these can be used successfully in National Resource Networks such as the National Electrical and Electronic Engineering Assessment Network. (White and Davies, 2000) This work allowed for the sharing of questions across Universities in the South Coast consortium of Bournemouth, Portsmouth and Southampton Universities. This resulted in an improvement in assessment creation at these institutions by giving more direct resources to assessment creators and thereby increasing the assessment creation efficiency.

This paper details the work at the Polytechnic to create a Question Bank for Assessment creation that can be further used in resource networks to share moderated questions across Universities, Colleges and even Community Colleges currently being rolled out in Malawi.

1.1 Overview

Assessment is an important aspect of higher education in the education of undergraduate students. It has a range of powerful impacts on what students and lectures alike do. A defined system of assessment and improving assessment has a huge impact on the quality of student learning (Boud and associates, 2009).

It is in this vein that Institutions of higher learning such as the University of Malawi have put a high priority on assessments. Assessment tells students what is valued and what they need to achieve to be successful in their studies. It captures their attention and study time, and acts as an instigator for harder work. Its results inform students of their progress, which in turn impacts on how they view themselves as individuals. (Ridgway et al., 2004).

1.2 Problem Statement

Information Communication Technology has been put in place in many of the University of Malawi’s constituent colleges, like the Polytechnic, in their core activities but very little has been implemented to assist in Assessment. The University uses ICT to support the assessment process but these systems do not help in the adherence of assessment concepts and principles that help to ensure that the assessment given to learners meets the University standards.
Assessment systems drive education, but are themselves driven by a number of factors, which sometimes are in conflict. To understand likely developments in assessment, we need to examine some of these drivers of change. One such driver is the need for increased access to education to insure inclusivity in education which is in like with developing nations Millennium Development Goals (MDG’s). (National ICT Policy, 2013)

Technological solutions such as E-learning systems are thought to by some to be the main method of achieving this. As the University moves toward these goals it would be necessary for it address the problem of having Assessment artifacts in manual scripts, which cannot be delivered over Electronic means. Therefore this paper seeks look at efforts to create a question bank as a future solution to sources of questions for e-assessment and that will address the problem while still capturing good practices in assessment development.

1.3 Aims and Objectives
The work looked at in this paper aims to develop a question bank that will capture assessment questions at their source, in this case the Assessment creator. The aim is to capture the current process of assessment creation using all its checks and balances to create higher learning standard summative assessment materials. It then seeks to ensure the long term storage of these assessment materials to be used for further assessment activities of any distinction.

The information seeks to create a system for inputting questions derived from:
1. Lecturer’s own perspective of teaching material
2. Prescribed or recommend reading text book Questions
3. Previous Assessment Questions including the modification of such questions.

The system will also accept supporting assessment information like Question weighting or grading and model answers.

The aim is the creation of a system that can work with other Higher Education systems and will deal with issues of interoperability in this case the ability to integrate its questions in to other Questions banks and the ability to be shared on Resource network. These could be stand alone options like Question Mark or those in Virtual learning environments like Moodle. It will also be a system that can be accessed over several different devices seeing that Universities employ several device usage policies such as Bring Your Own Device (BYOD) and others.

Another main objective to create a system that will be easy to maintain and improve by using a model view controller development model that guides development in a well documented framework. The CodeIgniter framework was selected for this purpose. The system should also be a user-friendly application following proper heuristic guidelines and be well documented for programmer and users alike.

2.0 Assessment
Assessment is central to educational practice. High-stakes assessments exemplify curriculum ambitions, define what is worth knowing, and drive classroom practices. It is essential to develop systems for assessment which reflect our core educational goals, and which reward students for developing skills and attributes which will be of long-term benefit to them and to society. (Ridgway et al., 2004)
There has been a remarkable growth of interest in the assessment of student learning and its relation to the process of learning in higher education over the past twenty years. This interest has been expressed in various ways – through large scale research projects, international conferences, the development of principles of assessment that supports learning, a growing awareness of the role of feedback as an integral part of the learning process, and the publication of exemplary assessment practices. (Joughin, 2008)

Despite the recent growth in interest noted above, assessment in higher education remains under-conceptualized. This paper takes into account the significant contribution to conceptualizing key aspects of assessment, learning and judgment carried out by the University of Malawi’s constituent college, The Polytechnic.

2.1 E-assessment
Assessment has always been a vital part of learning and with the coming of computers, computer aided or computer-based assessment has evolved greatly. The traditional forms of testing or assessment are objective, summative, diagnostic, formal and informal and others. These need to be carried over into the electronic and online world with the tools that come with computers used to the betterment of assessment (Sclater and Conole, 2006). These tools include automated marking, storage of assessment artifacts and adaptation of questions to match student ability to name a few.

Therefore e-assessment is basically the traditional assessment brought over to the devices with computing power and adapted to use the different capabilities of this new environment. The literature available on e-assessment points to an enriched form of traditional assessment delivered by electronic devices with computing power.

As predicted by Ridgeway et al. (2004), computer-aided assessment (CAA) now forms a significant part of many students’ experience of higher education, especially for subjects with a significant mathematical/analytical content and especially at the lower levels (years 1 and 2) where assessments typically test more mechanistic skills and techniques.

Several mature technologies now exist that can reach beyond their intended audience and discipline, meaning that e-assessment looks likely to be increasingly pervasive, for example in schools or for in-service training of numeracy skills for the general work-force. Such assessment should not only simply grade students, but also should promote learning, which means that effective questions will need to be based on sound pedagogic principles. (Greenhow, 2015)

2.2 Evaluation of Assessment Artifacts
A good question bank should be able to be used in assessing factual, conceptual, procedural and metacognitive knowledge (King, 2005). This paper will look at the use of software to streamline the addition and creation of questions into a single repository of questions. This seeks not to change the process of assessment creation but to use a simple framework to evaluate the principles of the current assessment creation method at the University against this framework.

Studies have been made to formulate a framework to depicted by King, with three key drivers in learning-oriented assessment. This simple framework argues that it is these three elements, learning-oriented assessment tasks, student engagement with feedback and developing
evaluative expertise as depicted in Figure 1.1 that impact significantly on the kind of learning which students derive from the assessment process.

![Figure 1.1: Learning-oriented assessment framework](image)

The apex of the framework is represented by the assessment tasks, which students are carrying out as parts of the courses for their degree programs. Assessment tasks strongly influence how students direct their efforts. Therefore the access to assessment artifact material is of use in both as a tool by students to measure knowledge and for lectures in assessment creation.

There is need to make distinctions between the various types of assessments. They are summative, formative and diagnostic assessment types. Summative assessment is used for grading purposes such as final semester exams. Formative assessment is used by educators to gain feedback to assist in the learning process. While diagnostic assessment is used to determine the learners prior knowledge (Bull and Mckenna, 2004).

Students have always learned strategically based on what they perceive as the assessment requirements of their course, however increasing demands on their time means that obtaining a qualification is the fundamental driver for growing numbers of learners.

It has been made apparent through the assessment creation process indicated in documentation available, that the University like other Institutions of higher learning sees, the realization of a qualification, as the main use of assessment. And this paper looks at the work to create a system which will ensure that lectures have access to assessment materials that have been assessed to be learning orientated assessment artifacts, and allow for the development of evaluative expertise and can be used for the student to engage with the assessment questions and provide adequate feedback throughout their learning experience.

These will be thought to be achieved by forcing the assessment process to adhere to peer review processes and allow for student access to ensure that students are able to also evaluate the questions towards their learning material.
2.3 ICT in Assessment

ICT provides a link between learning, teaching and assessment. In school, ICT is used to support learning. Currently, we have bizarre assessment practices where students use ICT tools such as word processors and graphics calculators as an integral part of learning, and are then restricted to paper and pencil when their ‘knowledge’ is assessed. (Ridgway et al., 2004)

This further raises the argument that ICT should be used to a greater extent in the assessment process. Either like in this case to simply provide a system to feed high quality questions in a central repository or to aid in assessment delivery (online or e-assessments) or as aid to marking assessments ICT can play a big part in improvement of assessment.

Question mark Perception is an example of a complete assessment management system that enables assessors to create questions and organize them into exams, quizzes, tests or surveys. The system also allows for the scheduling of assessments and delivery of these systems in a variety of electronic means, together with the viewing of results in twelve different report types. (Questionmark Perception, Getting started Guide, 2011)

The proposed assessment solution will seek to take the concept of the creation of questions from systems like Questionmark Perception but seek to use the other University systems like Student Management Information Systems for viewing of results and delivery of assessment in the future to Moodle and currently to paper based assessment delivery. These tools will be evaluated further under interoperability of University ICT systems.

3.0 Methods and Methodology

This section methods, tools and methodology used in creating the proposed question bank. The process of collecting system requirements was done through a process of collecting University provided literature on the moderation and assessment processes and through a self-administered questionnaire. This section will also discuss the various tools used in the system development. An agile development methodology was used to develop this system using good programming practices such as version control systems, using development frameworks and the of good programming standards and proper documentation.

3.1 Evaluation of Current Systems

Being a member of the ICT team at the University allows for a greater knowledge of the ICT systems. The University currently runs several ICT systems that support the core activities of the University. These systems include student information management systems, a virtual learning environment, several types of accounting systems and even online library Management systems. All these systems can be accessed over networks and have central processing and storage architectures. This is due to its work-forces requirements.

Network systems allow for collaborative work to be done on the system by teams in different offices, campuses and even geographic locations. University staff needs access to systems all the time and across networks to work on data that needs to be manipulated by several different players. This makes systems server based systems accessed over networks to be best suited. Some lecturers still lecture while studying postgraduate courses abroad using Virtual Learning Environment’s like the University’s Moodle E-learning systems. They also need access to the student access management system for inputting student progress and student records.
The University has infrastructure to support server-based systems that it currently runs. The University also always access to these systems over the internet via an ISP that offers Internet Services. This is then in line with the University’s policy on ICT equipment. Lectures, support staff and students are allowed access to the Universities personal computers for academic and work purposes. They are also allowed to access University systems using their own devices over BYOD policy. This makes web based systems the best fit for a University. A server-based system would also be best suited to be accessed across national resource networks.

3.2 Evaluation of the Assessment Process

An evaluation of the Assessment process was undertaken through the collection of assessment moderation literature made available at the University, general observation, and information solicited from lecturers involved in the process from the Mathematics and Languages Department though a questionnaire.

The Moderation process is Uniform throughout the University departments and the Mathematics department assessment has assessment material that uses both language like statements and the use of symbols as well. Each University Department has a moderation coordinator that is the department deputy head. The coordinator facilitates the process of moderation. The Head of Department facilitates a meeting to plan the department’s activities. At this meeting a schedule for all activities is made together with the assessment creation schedule to be ready for the final summative assessment at the end of semester.

The study used an open ended self-administered question questionnaire pertaining to the Assessment moderation. The assessment creator, who can be any member of the department, starts the process by creating an assessment artifact. The respondents included a staff associate, an assistant lecturer and a full lecturer plus the deputy head of the department. Respondents are from the faculty of applied sciences and the department of mathematics and statistics. All respondents have at one point served as either an assessment creator, or moderator. Only one is currently serving as a Moderator coordinator.

The role of the assessment coordinator involves creating assessment tools that are effective in assessing students' retention of the content covered over the course of the semester and discriminating among the students in terms of those that are excellent, very good, good, average, and poor. The assessment creator’s responded that they create questions by:

- By selecting questions from different books but pertaining to the content I lectured in.
- Creating Short answer questions and Essay-type questions
- Using materials used for teaching, course outline objectives, and other end of book exercises

Other methods used to create questions include:

- Text Book Question Banks (Hard Copies),
- Past Assessments (Reuse of past Questions),
- Past Assessments (Modifying past questions),
- General Internet Searches
The role of moderator involves critically looking at the assessment tools created by other lecturers and ensuring that they are up to standard in terms of the language used to create the assessment tools and the level at which they are assessing students.

Moderator’s responses to the tasks they carry out included:

- Evaluating examination papers from a colleague in the same field.
- Checking if the test items
  - are in line with the objectives of the course syllabus
  - meet the required standards of the level of the learners
  - well-structured and legible
  - are compliable in the time allotted
- Checking whether there are any technical (e.g. mathematical) errors
- are looking at questions created by other assess to give an opinion as to whether they are of good standard

These tasks are put in place to ensure that the assessment criteria meets the standards of higher learning and can be used to educate learners to be able to adhere to Blooms taxonomy of learning objectives. A good question bank should contain questions used in assessing factual, conceptual and procedural and metacognitive knowledge (King, 2009). On completion, a check list in the form of completion form is filled out and handed over to the coordinator.

The questionnaire also discovered that respondents felt that any system for the assessment creation would benefit them by:
  - Making sourcing of assessment materials easier
  - Offering a variety of test items hence increasing chances of validity of the exam
  - Saving time and resources.
  - Helping to reduce the time spent on formulation /creating the assessment questions
  - Being a ready source of questions that can be tweaked and reused.

The respondents thought that students would benefit from this by:
  - Enabling them to prepare adequately for assessments
  - Students would be able to revise course work through a question bank hence help them prepare well for assessment.
  - They could be in a better position to understand how the Lecturer asks questions, what they look for in a question and be well prepared i.e. they could analyze the questioning technique and will prepare well
  - It would be a repository of questions with topics that may come up in an exam.

The respondents also felt that the necessary items that need to be stored for a Question bank to be stored where:
• Question Weight,
• Question Content
• Assessment Title,
• Assessment Period,
• Question Number,
• Question Time Allocation,
• Paper Time allocation

Figure 2: Moderation Process Diagram

The process can therefore be noted as in the diagram above. It starts with assessor who submits the assessment within the department timelines. The coordinator receives them and then selects moderators or in some cases shares to the whole department. The moderators then moderate the questions. They then fill out the moderation form that has a detailed check list of things to moderate on. This is submitted to the coordinator who then returns the comments to the assessor who works on the questions and then returns the reworked questions to the coordinator. The process either ends here and a final paper is accepted for the assessment or the processes are repeated from the selection of moderators (different moderators may be selected).

3.3 System Development Considerations and Methodology

After the process was evaluated it was necessary to document the evaluation and analysis in such a way that the relevant inputs, outputs and processes would not be missed. The evaluation of current University systems discovered that currently most of the systems that directly support student learning are browser-based applications. This was done to accommodate the access of these systems from several devices from users running different
operating systems and varying geographical locations. Therefore a similar type of application is suggested here for the same reasons as the other systems, accessibility over networks using varying operating system devices.

3.3.1 Interoperability
Interoperability describes the extent to which systems and devices can exchange data, and interpret that shared data. For two systems to be interoperable, they must be able to exchange data and subsequently present that data such that it can be understood by a user. (HIMSS, 2015) Any system that is to be created and used in an environment must have the ability to work with other systems and share data for common organizational goals.

The browser-based systems available at the University that directly support student learning are the Student Management Information System (SMIS), and Moodle a Virtual Learning Environment (VLE). SMIS is a PHP and MYSQL based application created in house at the University for the tracking of student data. It allows for the inputting of grading, financial and demographic data for students.

Moodle is open source or free software (GPL). It is written in PHP. It will run on most common web servers, on common platforms. It requires a database, and will work with MySQL, PostgreSQL, Microsoft SQL Server or Oracle. Moodle focuses on providing an online space for teaching and learning, rather than any of the other systems that an educational organization might need. Moodle provides a basic implementation of the other functionalities, so that it can function either as a stand-alone system or integrated with other systems. The role Moodle plays is normally called a virtual learning environment (VLE), or learning or course management system (LMS, CMS or even LCMS). Brown, A. & Wilson, G. (2015)

These two systems support assessment at the University by either keeping record of student progress or as an assessment delivery method. All student grades are stored in SMIS and some lectures use Moodle for formative and diagnostic assessment. However all summative assessment is done through written papers.

Therefore any Question Bank system had to be created with the thought of inoperability in mind. Since PHP is the common programming/scripting language together with MYSQL for database connectivity for systems at the University, this was the scripting/programming language chosen. To keep up to date with good programming principles a Model View Controller (MVC) framework, Codeigniter, was decided upon.

3.3.2 Defined System steps
From the evaluation and analysis of the process of assessment, the steps of the process where ascertained as follows:

The assessor produces a hardcopy of the assessment during the said timeline for the department. He/she then submits this to the moderation coordinator who then selects specialists for that area or subject to moderate the test paper. This coordinator can also decide to share the assessment with the entire department to solicit comments from all members.

This is then moderated with the moderators filling out a moderation form that serves as a checklist to ensure a thorough and in depth process of assessment quality assurance. Then the submissions are submitted to the coordinator who is the deputy head of department and again in hardcopy on the moderation form.
The moderation coordinator then receives the changes and then resubmits to the assessor who then edits his/her questions if necessary according to the responses. They then resubmit to the coordinator who can either ok the paper for submission in portable document format or restart the moderation process.

Hence the Steps in the Process are:
1. Submission to Coordinator of draft assessment
2. Coordinator identifies Moderators
3. Submission of Questions to moderators
4. Moderations process takes place
5. Moderators submit moderation form
6. Coordinator redirects comments to assessor
7. Assessor makes edits
8. Assessor resubmits to Coordinator
9. Coordinator accepts paper as final or repeats step 3

3.4.3 Methodology
After a complete evaluation of the process of moderation and taking into account all the considerations, an agile methodology of development was decided upon. This will involve an incremental systems development in an event-driven development cycle using the model view controller framework.

The development will centre around the activities of the key players seen in the process. The identified players are:
- Assessor
- Moderation Coordinator
- Moderator
- Students

Use cases were developed for the processes described in figure 2 and an incremental development model was used to incrementally development or modules and functionalities for each user.

Each use case contained these attributes:

Background Information:

Table 1: Use Case Background

<table>
<thead>
<tr>
<th>Use Case Title</th>
<th>Version</th>
<th>Package</th>
<th>Summary</th>
<th>Primary Actor</th>
<th>Secondary Actors</th>
<th>Inherits</th>
<th>Includes</th>
<th>Extension Points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A typical sequence of events

Table 2: Sequences

<table>
<thead>
<tr>
<th>Actor Stimulus</th>
<th>System Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 [User steps]</td>
<td>2. [Question Bank System Response]</td>
</tr>
<tr>
<td>3.</td>
<td>4.</td>
</tr>
</tbody>
</table>

Relevant Information:

Table 3: Relevant Information

<table>
<thead>
<tr>
<th>Post-condition(s)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>[HIGHEST only ]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outstanding Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Any questions or issues that must be clarified before this Use Case is complete]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Name and contact details of the person who wrote the Use Case]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Any notes about assumptions, special cases, or decisions concerning this Use Case]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Version History</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Description of changes that have occurred since version 1.0 was released]</td>
</tr>
</tbody>
</table>

Alternative sequences of Events from the typical sequence of events:

4.0 The Application

4.1 Welcome screen
All the user cases will go through the welcome screen. So instead of including it into all the user cases it was case studied on its own. The system has a welcome screen that is the first thing that user sees when entering the system. Ideally the link to the system would be found on the University website. When this link is clicked it will divert the user to the welcome screen. A brief explanation of the system can be found on the welcome page together with options for moderation process or simple question bank search. The system welcome was created as below.
The search option will give the user access to a simple search or filter questions by Coursecode, question content or year when question was used. This can be seen in the screen shot below.

**Figure 4: Search Screen**
4.2 Assessor and login Use Case:

Input View

The assessor question input case. This involves the assessor or moderator or coordinator being already registered in the system by the coordinator. They then enter their credentials in the login screen as below.

![Login Screen](image)

**Figure 5: Login Screen**

The login credentials are provided the administrator of the system. Existing members of the system can add new users. This can be done in the login area that will be seen in the register section.

Once the assessor has successfully entered the system they will be presented with a user area as seen below:
The screenshot above shows the Question bank main area. This screen has all the main menu elements for the system including the current dashboard screen. The Other sections are moderation, reports, register, search and logout.

The main dashboard area has the main area of the system, which is Assessment artifact creation. This area allows for the inputs of:

- Course Code
- Question Title
- Question
- Model Answer
- Weight
- Semester
- Year

The assessment also allows for the entered questions to be edited or completely deleted. The pencil symbol will give the assessor access to the window for editing question inputs. This allows for edits to be made to the appropriate section of the question. Like shown in the image below:

![Figure 6: Assessors Screen](image-url)
The left sidebar in the dashboard is dedicated to the comment area. This can be used to add comments to this assessor area obtained from the moderation report. The assessor can then tick off every comment he adds to his questions by using the tick. He can also delete the comments by using the x symbol. This feature is common throughout the system.

When the assessors feel they have completed all their tasks in this area they can now select the notify coordinator link. This link will allow the user to send a notification of completion mail to the coordinator. Please note this system is currently only for the mathematics and statistics department as per the evaluation. So the email will be sent to the coordinator for the Mathematics and Statistics department who is the deputy head of department. The email address is hardcoded so that it can only be changed from the backend. The snapshot below shows the notification screen.

This area will allow the assessor to enter their Name and Email and any other relevant message for the use of proper coordination or moderation of the proposed assessment material. Currently this area could be used to state the assessment materials timeframe. There was a conflict between trying to force the assessor to enter a time frame for each question or to allow for a timeframe for the entire assessment. This problem arises due to the fact that all the researched past papers only contain a full paper timeframe but the system seeks to allow individual question artifacts to be stored. This would need to be furthered researched to find an acceptable method of indicating time per question if acceptable by assessors or to just have the total amount of time for the full paper tagged to each question.
4.3 Processes

This section includes the processes of edit, delete and option select. The questions inputted into the system have a functionality to allow the assessor to edit the contents. This could be as a result of comments made during moderation. The system also allows for deletion of questions and comments. The x symbol allows for these actions for both. The correct tick ✔️ in the comment section allows for the user to highlight or highlight comments that have been worked on and can be used as a checklist for accommodating changes.

4.4 Error Messages

The assessor’s area has several error messages that appear. Each area has validation methods to ensure that the user follows the right critical when working in the system. The validation scripts are created using codeigniter tools as well as java-script pop ups and flash areas that appear in the system screens. The login area has been set to validate and confirm the username and password fields. The username and password are verified against the username and passwords found in the user table of the systems database. Currently the admin password is hardcoded into the system. The application will finally be altered to include a user administration page for all users.

Any miss in inputting the username and password into the system will result in the system responding to the user with an invalid login message. The system is case sensitive and will only accept inputs that match the system database record exactly. The type of input error response can be seen below.

![Figure 9: Invalid Login](image)

The user will be prompted to enter the correct credentials to access the protected session areas. Both the username and password are considered required fields and any omission of these will prompt the error shown above. This allows for some system security to ensure that there is never any unauthorized access to the system. If the User enters the correct credentials they are brought to the questions input page with the full dashboard.

The assessor area also has some validation checks in place. The system will output errors for any errors made in inputting empty fields for required areas which are all the areas except for the model answers which have been identified through the questionnaires as a non-required area and is optional. Any omission in these areas will result in validation errors appearing here. A snapshot has been shown below.
Figure 10: Validation Error

The screen shot depicts the required fields omitted in the system input. This is prompted upon clicking the create button without having completed the required inputs properly.

The system also has x symbols in the question side bar and the comments side bar. These symbols represent the delete action. The action can be called by clicking the symbol. A validation method appears to ensure that you are certain that you want to actually carry out this action. This is to prevent accidentally deleting a desired item permanently. The validation confirmation screen can be seen below.

Figure 11: Delete Confirmation Message
4.5 Coordinator and login case:

The coordinator uses the same login case as explained in the assessors case. Although the assessor is the main user of the system the coordinator has the admin login and is responsible for registering assessors and moderators alike. The coordinator logs in with administrative rights and then registers the users.

Coordinator Input Views
The coordinator fills out the form for the moderators and assessors and sends an email to the selected member of staff to login and perform their tasks. The process of information sharing is purely by email. The system notifies by email. And the coordinator sends emails to inform the users that they need to perform their tasks.

![Register View](image)

**Figure 12: Register View**

4.6 Moderator Use Case:

Input View

The moderator area has a search area that allows for the moderator to select the material to moderate on. The moderator enters the course code for the subject he wants to moderate on. The system will display only that course. The system is designed only to store active questions for moderation. When questions have been used for assessment they can then be removed from the current database to the search database for where all questions can be viewed. These questions will also be transferred into the Moodle database for formative and diagnostic assessment by lectures and self evaluation by students.

This area also has the comment area. The comment area allows for comments to be made on questions seen in this area. The comments made are not saved in this area but are added to the assessor comments section. Once the moderator clicks the link for the moderation form the comments get moved to the assessor seen below.
When the assessor finishes looking at questions here they fill out the moderation comments form. Here they check that the assessment meets the criteria. All the questions are required and the moderator must answer all the questions. This is the acceptable format for comments and will all be fed into the reports section of the application.

![Moderation Report Form View](image)

Figure 13: Moderation Report Form View
When the moderator completes the form they can then submit it. They then send the completion email to notify the coordinator that the task has been completed. The form is the same as the notification form for the assessors completion of tasks.

**Outputs**

The moderator outputs consist of the questions for the particular searched paper code. The moderator will have filtered all the course to moderate on and view only relevant content. Then all the inputted comments can be searched again according to course code to filter out the irrelevant sections. The headings have pop up titles that appear on a mouse arrow hovers over them for the complete questions for Q1 up to Q12.
Processes:

The search process allows for the moderator to filter out all the non-essential questions and focus on the correct questions. This is also true for the report view where the user accessing this page can also filter out unnecessary comments and focus on the necessary questions.

4.7 Search Case (Question Bank area)

This area allows for the assessor, coordinator to search through the complete database of questions. This can be used to assist in creation of new assessment material.

![Figure 16: Question Bank Search Area](image)

5.0 Discussions and Conclusions

The Question Bank solution looks at creating a method of collecting moderated questions using an already existing tested methodology of creating higher learning assessment questions for summative testing. There for the system allowed for the assessor to input the questions that they create from their various sources via an online system. The lecturer still however has control over the process of question creation and ensures that they are used in assessing Factual, Conceptual, procedural and Metacognitive Knowledge.

The system also caters for a level of quality assurance. To ensure that the lecturer adheres to the concepts of Blooms taxonomy of learning framework for approaching the problem of assessing for higher learning outcomes, checks and balances where added. The system incorporated a moderation approach to ensure that the assessor adheres to this standard. The moderator has to ensure that the paper meets particular criteria pointed out in the moderation form. This form is main deliverable of the moderation process and must be completed and submitted to the system. The system also allows for a notification to be sent to the Coordinator via email to ensure that this process has been done successfully.
A simple framework argues that these three elements, learning-oriented assessment tasks, student engagement with feedback and developing evaluative expertise that make up a good assessment system. (Bull & Mckenna, 2004) Hence the need to evaluate whether the system created allows for these elements to be included in assessment and to what extent.

The lecturer or assessor is main actor in the assessment creation process and is there responsible for these elements to be addressed in assessment. This system only aims to create a tool to aid them. The system ensures that the assessment tasks and questions are of a higher learning standard that are learning orientated and develop evaluative expertise by forcing the lecture to adhere to these standards through moderation. For instance in question 8 of the moderation form it says “Do the exam items test the various levels of: knowledge comprehension, analysis, synthesis, application evaluation etc.”. This question amongst others seeks to ensure that the two elements are adhered too.

The other element of student engagement with feedback seeks to be addressed in the provision of access to past assessment materials through the search system. This will allow students to properly prepare for assessment by engaging with the material in easy to access system and then engage the lecturer throughout the course on items where they need clarification. Therefore I feel that the system does act as an aid to creating assessments for higher learning to a very high degree.

Other system objectives included some security features that I feel have been addressed by using a framework that includes database security features including data injections. The use of sessions to secure page content and the use of email field hiding to protect the notification page from being attacked from spam bots.

5.1 System Testing
Inputting sample tests collected from lecturers was met with general success when testing the system. The system allows for the input of symbols as well but would need the expertise of a seasoned computer user. This will need the use of shortcut keys to input special symbols used in Mathematics and Statistics.

5.2 Future work
The current system will still need a lot of work for it to be properly implemented. Some tasks that were planned for like user evaluation were not carried out due unavailability of staff due to a student strike at the University causing some lecturers not to be physically available on campus. This evaluation would have streamlined some need for interface changes and features that could improve the system.

However an expert analysis produced a list of proposed future work:

- Creation of a user administration area
- Creation of a suitable time per question system
- Creation of a print function to allow for the printing of question papers from system
- A software keyboard for symbols, to allow for specialized symbols to be inputted into the system.
- Creation of a function to move questions used in assessment from the moderation database to the general assessment database for students to utilize
5.3 Conclusion
The University of Malawi’s constituent college The Polytechnic has a very good process of assessment creation. They have put in place the necessary measures to ensure an educated student that can be able to enter meaningful employment in various sectors of society. This project sought to mirror this process without losing out on any of the current good but manual practice features of the current system. It has to a very good level succeeded in that, but it has, however, not been tested in a real assessment situation for there to be a true verdict on its ability to aid in the assessment process.

Similar projects such as the National Electrical and Electronic Engineering Assessment Network were successful in creating a task force to create a system that could be used across Universities.(White & Davies, 2000). The issues include a generalized naming structure, keywords for searches and system of grading questions into levels that can be used across Universities and Colleges. The emergence of technical community colleges and private Universities can benefit from experienced knowledge from established institutions of higher learning like the Polytechnic. But the questions and artifacts need to be structured and delivered in a method that would best benefit different institutions.

With the establishment of the National Council for Higher Education (NCHE) and the development of MAREN (Malawi Research and Education Network) the structures for organization and delivery of such question banks are possible. This paper seeks to bring to light the benefits and the work done towards this goal of a unified question bank system for national use.

6.0 References


Biography

Chifundo Chilivumbo is an IT professional currently working in the field of E-Learning and E-Health Systems. He has over 10 years’ experience working in the IT Sector. He is currently working as a the E-Learning Specialist for the University of Malawi’s constituent college The Polytechnic and also serves as a Senior Consultant for Vital Wave evaluating Health Systems in Malawi. He holds a BSc in Computer Science and an MSc in Software Engineering. He has a passion for using ICT for development in Malawi and developing countries.
Implementing perfSONAR in the South African National Research and Education Network

Kevin DRAAI¹,², Roderick MOOI¹,³
¹Council for Scientific and Industrial Research, P.O. Box 395, Pretoria 0001, South Africa
²Tel: +27 841 2342, Email: kdraai@csir.co.za
³Tel: +27 841 4111, Email: rmooi@csir.co.za

Abstract
The South African National Research Network (SANReN) serves over 1 million users who expect high performance. To ensure optimal operation, rapid detection and correction of abnormalities is crucial. PerfSONAR is a network measurement toolkit that can be used to test and monitor end-to-end network performance and achieve this goal. The tools provided can verify the limits of a network (primarily in terms of throughput and loss/latency) and reveal faults and issues. The SANReN team use perfSONAR to evaluate the network on a hop-by-hop basis with test results conveyed through a dashboard for rapid visualisation and alerting. There are many cases where it has proven its utility in the SANReN network. This paper provides an overview of the SANReN and perfSONAR prior to covering the deployment scenario and use cases to highlight the benefits provided.

Keywords:
perfSONAR, network performance, network troubleshooting, NREN advanced services.

1. Introduction
Measuring and monitoring the performance of the South African National Research Network (SANReN) has become increasingly important because of the complexity and size of the network. In order to report on the actual delivered bandwidth and quality of the network, throughput, loss and latency were identified as meaningful metrics. Following an investigation of the available tools, the perfSONAR toolkit was identified as the most suitable solution for measuring and monitoring these network performance metrics. The SANReN competency area (CA) of the Council for Scientific and Industrial Research (CSIR) has been deploying perfSONAR nodes on the network since 2012. We now have 15 x 10Gbps dual-homed nodes covering most of the national backbone of the network and both international links. This paper provides an overview of both the SANReN and perfSONAR prior to expanding on the SANReN deployment details. Thereafter we reveal some troubleshooting scenarios where perfSONAR proved its value before concluding the paper.

7 Available at: www.perfsonar.net
2. SANReN Overview
The SANReN was conceptualised in 2003 and implemented by the Meraka Institute of the CSIR under contract to the Department of Science and Technology (DST) from 2008 onwards (TENET, 2013). The SANReN has a national backbone capacity of 10Gbps. Typical client handoff is 1Gbps though some main campuses connect at 10Gbps. The backbone and metro networks are deployed in ring topologies for performance and redundancy. The SANReN high-level topology is shown in Figure 1.

![SANReN Topology](image)

Figure 1: SANReN Topology (by S. Mammen <smammen@csir.co.za>)

The SANReN CA design and build the network while the Tertiary Education and Research Network of South Africa (TENET) operate it. Together these two parties form the South African National Research and Education Network (SA NREN). The SA NREN provides value-added advanced services such as eduroam and video conferencing to its customers and beneficiaries. perfSONAR is currently regarded as an internal service intended for customer-facing expansion.

3. PerfSONAR Overview
PerfSONAR is a joint project that was started by several Research and Education (R&E) networking and other interested parties. The current uses of perfSONAR include the collection and publication of latency, achievable bandwidth, utilization and network topology data as well as the assisting with the diagnosis of performance issues (Tierney, et al., 2009). The aim of the toolkit is to provide a universal representation of network performance thereby aiding network engineers with trouble-shooting and optimisation tasks. PerfSONAR
is built on standard Linux distributions enhanced with the web100 kernel. The configuration and tuning is done via the command-line (back end) and tests are scheduled on the web interface (front end). Since our first use of perfSONAR, we have witnessed constant improvements in the toolkit with new features, reliability and support for system administrators in each new version. The mailing list is active, responsive and of high quality⁸.

3.1 Version 3.5
The latest version of perfSONAR was released in September 2015. It comes with a new web interface, support for alternative installation methods as well as enhanced auto-configuration and central management features to assist with large deployments. More information on version 3.5 can be found at⁹.

3.2 Features and Uses
The perfSONAR toolkit boasts many features and components. These include measurement tools, measurement archive, host management tools, data analysis tools, and a lookup service (Tierney, et al., 2015). The measurement tools include iperf3 (throughput), bwctl (scheduler), owamp (loss/latency), owping (one-way ping) and traceroute. The central measurement archive stores all measurement data in an easily accessible esmond database¹⁰. Host management tools allow the user to configure the node details, running services, NTP servers and scheduled tests. Test results can be viewed from the web frontend where on-demand ping and traceroute tests can be executed as required.

In addition, the perfSONAR toolkit features a mesh capability. This enables an administrator to configure a mesh of tests between any number of perfSONAR nodes on a network. The mesh configuration can be centrally hosted and retrieved by all nodes which then execute the relevant tests and store the results. A central measurement archive can also be used to store the results (which are pushed to the archive by the nodes on test completion). The SANReN perfSONAR team uses both individual as well as central storage for redundancy and quick access to results.

It would make sense to visually represent these tests between perfSONAR nodes in an easy-to-read central dashboard setup. The Monitoring and Debugging Dashboard (MaDDash)¹¹ is designed for this purpose. With this feature, throughput and loss/latency tests can be viewed between perfSONAR nodes as a grid, issues can be rapidly identified and detailed test results accessed from a central interface. The SANReN perfSONAR dashboard can be seen in section 4.

The Network Diagnostic Tool (NDT) and Network Path & Application Diagnostics (NPAD) tools are included with perfSONAR and assist in identifying bottlenecks¹². They allow a user to diagnose internal network problems and bottlenecks by testing the path between the local computer and the perfSONAR server. NDT provides network configuration and performance

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⁸ see: http://www.perfsonar.net/about/getting-help/
⁹ http://www.perfsonar.net/
¹⁰ http://software.es.net/esmond/
¹¹ http://software.es.net/maddash/
¹² https://fasterdata.es.net/performance-testing/network-troubleshooting-tools/ndt-npad/
testing to/from and end user’s workstation. Lastly, the perfSONAR project provides a lookup service directory where all registered nodes across the globe can be discovered. The SANReN perfSONAR deployment is discussed in the following section.

4. SANReN PerfSONAR Deployment
The SANReN CA (with TENET’s assistance) have deployed perfSONAR nodes across the national backbone as well in London (Telecity) and Amsterdam (NikHef) [connected to the UbuntuNet Alliance routers]. The International nodes are used to test and monitor the throughput and latency of the SEACOM and West Africa Cable System (WACS) links that provide international connectivity to the SANReN network and TENET’s customers. The rest of the nodes on the network are deployed at locations on the network that allow tests to cover critical portions of the national backbone. We use DELL PowerEdge R320 rack servers with Intel X520 NICs to enable 10Gbps testing. SANReN also keeps some mobile nodes for ad-hoc troubleshooting up to 1Gbps.

4.1 Topology and Tests
We have implemented a mesh of tests between our perfSONAR nodes. These tests run on a hop-by-hop basis in an effort to troubleshoot each layer 3 network segment on the backbone without duplicating coverage. Sometimes there are a few hops (routers) between the perfSONAR nodes which could affect TCP throughput. To eliminate this and increase the visibility of problematic paths, more nodes can be deployed. Alternatively, temporary routing changes also assist in troubleshooting paths that span multiple routers and switches or use mechanisms like Equal-Cost Multi-Path. To test a routing change, ad-hoc tests can be run via the web interface or the command line of any perfSONAR node (nodes can run tests between other nodes if required). The SANReN perfSONAR deployment logically overlays the

13 http://software.internet2.edu/ndt/
14 accessible at: http://stats.es.net/ServicesDirectory/
national backbone creating a pseudo-ring topology. The deployment is shown in Figure 2.

![Figure 2: SANReN perfSONAR Topology](image)

All the nodes on the network are dual-homed. This means that throughput and latency tests are separated. It also has an added advantage of connection redundancy. Throughput tests are run on the 10Gbps port and latency tests are run on the 1Gbps port. In this way throughput and latency tests don't interfere with each other.

4.2 MaDDash
The Monitoring and Debugging Dashboard (MaDDash) is deployed on a central node in the SANReN network. This retrieves all tests run between servers and puts it in a grid format as shown in Figure 3.
The dashboard is targeted towards Network Operations Centre (NOC) staff as there are thresholds set for when throughput drops below a certain value or loss greater than zero. When these thresholds are crossed, a state change is triggered causing the blocks to change colour and thereby reflecting a warning (yellow) or critical (red) state. Clicking on a block displays the detailed test results for that link. Utilising the perfSONAR toolkit, and the dashboard in particular, the SANReN CA and TENET staff have been able to detect and isolate problems on the network that were previously unnoticed and difficult to detect otherwise.

4.3 The Usefulness of perfSONAR in the SA NREN

PerfSONAR has proved its usefulness for the SA NREN in numerous scenarios. These range from poor throughput caused by improper configuration of routers on the network to physical problems on the links provided by telecommuncations operators. PerfSONAR picks up on these faults simply by indicating that the throughput, latency or loss measurements between nodes are not according to expectations.

PerfSONAR may further indicate that traffic between nodes is not traversing through an optimal route. An example of an incident where traffic was taking a suboptimal route was
when throughput tests were run between Durban and Amsterdam. The throughput was low so a traceroute was done to figure out where the traffic was going and it seemed that all the UbuntuNet Alliance traffic was traversing London before it got to Amsterdam. It was also found that all UbuntuNet Alliance traffic was going to Amsterdam first then back to UbuntuNet Alliance nodes in Africa. Figure 4 highlights the problem and shows the effect of correcting the traffic paths.

![Figure 4: Durban to Amsterdam Routing Problem and Rectification](image)

Jumbo frames need to be enabled for throughput of close to 10Gbps to be achieved. The 9000 byte MTUs need to be configured on the 10Gbps ports of the end nodes as well as routers and switches along the path between perfSONAR nodes. If this is not done, achievable throughput ranges between 1 and 2 Gbps (depending on path length) even for an uncongested 10Gbps link.

To test the TCP throughput of a link that is geographically long the buffer settings on the source and destination perfSONAR nodes need to be tuned to match the Bandwidth-Delay-Product (BDP) of that link. The latency (RTT) of these links are normally greater than 100ms. If the maximum buffer sizes on the source and destination nodes are too small then the throughput will not reflect the available bandwidth at that point in time. An example of an event like this on the SANReN network was between Cape Town and London (over the WACS). After correcting the buffer sizes, the TCP throughput went up from ~150Mbps to
7Gbps. Figure 6 illustrates this event.

Figure 5: Host Buffer Tuning Fix

On an NREN there might be link breaks. These breaks can be on dark fibre links or managed links and can be difficult to detect as a break or fault may result in degraded performance and not necessarily loss of connectivity. PerfSONAR picks up on these issues as well by indicating loss and low throughput on the link together with latency changes. Figure 7 illustrates an example of a fault between Pretoria and Durban.
The link break and restoration events are evident from the graph. Finally, Figure 7 shows the loss and latency events for one week while investigating issues on a link between London and Cape Town.

5. Usefulness beyond the SA NREN
Two further use cases are worth mentioning. The first is in the investigation of low throughput experienced by the SKA project site connected to the SANReN. The second was a faulty NASA router verified by one of our perfSONAR nodes increasing visibility due to the increased latency between the router and our node.

6. Conclusion
The SANReN team has deployed perfSONAR servers effectively measuring and monitoring the entire national backbone and both international links. The purpose of this service in the SANReN network is to monitor the performance of the network, assist in troubleshooting, tune the network to reach its full potential and assess whether the network can actually reach its potential given the current load on the network. After providing an overview of both the SANReN and perfSONAR, we proceeded to explain SANReN’s deployment and highlighted some use cases of the toolkit on the network.

The SANReN CA’s next steps for perfSONAR include additional community engagement, MaDDash email/sms alerts, integration of perfSONAR in new link procurements, increased mobile node deployments (for specific trouble-shooting scenarios) and contributing to the African perfSONAR mesh.

Bibliography


Biography
Kevin Draai is a SANReN engineer. His primary responsibilities are the implementation of services such as perfSONAR and Network Visualisation as well as Network Roll out and Inventory Management. He is currently studying towards an M-Tech in Communication Networks at the Nelson Mandela Metropolitan University (NMMU).

Roderick Mooi is an experienced software engineer who became part of the SANReN CA in 2012. His projects are focused on advanced (value-added) services development and include perfSONAR and the SA NREN CSIRT. Roderick has an M. Tech. in Information Technology. He also works ad-hoc on tools to improve team productivity as well as participating in network design and tender evaluation activitie
Learning from Somalia and Ethiopia – the NREN as a tool for Building National Expertise: A co-authorship between SomaliREN and the World Bank

Rachel FIRESTONE¹, Abdullahi Bihi HUSSEIN²

¹SomaliREN Secretariat, Industrial Road, Warta Nabadda, Mogadishu
Tel. +252619600611; Email: abdillahibehi@somaliren.org,
²The World Bank, 1818 H Street NW, Washington D.C, USA 20433
Tel. +12024589821, Email. rfirestone@worldbank.org

Abstract:
Countries in the process of developing their ICT ecosystem often face the challenge of end users lacking the skills and information necessary for using the new technological service to its full capacity. States recovering from conflict and emerging out of long periods of isolation tend to experience this imbalance in infrastructure and soft-skill development even more poignantly as they work to expand many services and sectors concurrently. Somalia is a good example of this as its national technical capacity is too nascent to deploy national Research and Education (NREN) infrastructure without importing external expertise. Yet past development experience in-country also demonstrates that reliance on outside expertise can underemphasize local knowledge development and result in institution ill prepared to avail of the technology at their disposal at development project completion. This paper takes a comparative analysis of NREN and education-based technology project experiences in Somalia and Ethiopia aims to explore how an NREN can not only avoid this pitfall, but how the unique services it can provide in addition to connectivity can act as a tool to building out the technical skillsets necessary to support a vibrant ICT sector and competitive developments in the STEM professions across the board.

Keywords:
National Research and Education Networks, Human Resource Capacity, Local Content Development, Fragility and Conflict, ICT infrastructure, Economic growth

Introduction:
As emerging economies take on the global playing field, and as countries move out of fragility and conflict, communications infrastructure is a critical enabler for rebuilding and bolstering the systems constituting a transparent and democratic state. Information communication technologies (ICTs) are also crucial to supporting national human resource

capacity to reach internationally competitive levels. Yet countries in the process of developing their ICT ecosystem often face the challenge of end users lacking the skills and information necessary to effectively utilize and maintain the new technological services in the first place. Where in-country technical expertise is nascent, country governments, donors, and private sector entities often import foreign specialists to set up facilities and infrastructure, at the expense of developing local technical capacity. States emerging from conflict and long periods of isolation tend to experience imbalanced infrastructure and soft-skill development particularly poignantly as they work to expand multiple services and economic sectors concurrently.

Yet communications infrastructure geared towards supporting higher education and research institutions has been shown to help fill national level gaps in local human resource capacity. National Research and Education Networks (NRENs) are a case in point as their demand aggregation lowers the price of bandwidth, while unique “middleware” services, such as Authentication and Authorization Infrastructures, and the role of a platform for value added services (VAS) such as grid computing and e-library facilities have been shown to dramatically increase the training and research resources available in-country. The following research aims to use a comparative analysis of experiences in Somalia and Ethiopia to explore how, particularly in the context of currently or recently fragile states, NRENs can support the build out communications infrastructure and the technical skillsets necessary to develop the and support the ICT sector and STEM professions at the national level.

Methodology:
Using a comparative case study analysis, research for this inquiry was conducted based on interviews carried out with NREN CEOs, ICT Directors based within individual universities, NREN network engineers, employees within national level communications and education ministries, university chairpersons and other administrators, and IT and Computer Science faculty lecturers in Somalia and Ethiopia. The research also included a desk study of NREN documentation collected by Somali and Ethiopian NREN organizational bodies, respectively the SomaliREN and EthERNet. Somalia and Ethiopia were chosen as contexts for study, given the following:

- **Somalia**—a state and economy working to rebuild in the aftermath of civil war, where local skill development has thus far been too nascent to deploy ICT infrastructure without importing expertise. At the same time, contracting foreign skillsets for one-time ICT development projects at the university level has a resulted in demand for local content development of administration platforms and curricula, as well as human resource development in-country.
- **Ethiopia**—a state that, while still deemed a fragile and transitioning economy by the international community, has experienced strong and broad-based growth over the

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18 See: Foley, Michael. “National Research and Education Networks (NRENs): What they are, the case for their establishment, and NREN activity in Africa,” World Bank Group draft working paper, October 2015.
19 See: http://library.fundforpeace.org/library/cfsir1423-fragilestatesindex2014-06d.pdf
past decade. In this context, Ethiopia has developed a functional NREN that supports national human resource capacity development by facilitating local content development wherever possible. In so doing, the NREN supports an array of value-added services used to disseminate network management knowledge, research outcomes, and training opportunities to under-resourced institutions across the country.

Research findings suggest that the physical infrastructure and community of practice provided by the NREN is particularly conducive towards national human resource development in the following three ways:

a) Supporting the development of a sector-wide ICT capacity building strategy for the higher education sector, through either top-down government driven, or bottom-up, member university-based consortium driven models

b) Supplementing under resourced universities through national and international university partnerships for establishing distance learning and exchange program-based training programs for graduate level degrees catering to network engineers and the STEM professions

c) Facilitating local content development through Train the Trainer programs, ICT infrastructure maintenance, and VAS development within national institutions

Background

The Ethiopian NREN, EtherNET, was established in 2001, is driven by a national higher education policy, and is funded entirely by the government. EtherNET uses the infrastructure of the nationally owned Ethio Telecom to connect 36 public institutions with both REN connectivity and commodity Internet. The universities contribute towards the last-mile connectivity from the federal budget allocated by the Ministry of Education. The NREN organizational structure consists of two tiers of membership bodies, with a more select Board of Governors chaired by the Minister of Education as the overall decision-making body. The two membership bodies consist of the presidents of the member public universities meeting on a semi-annual basis, and then an ICT Directorate comprised of the universities’ ICT directors and aimed at channeling technical concerns and interest to Board of Governors.

In contrast to Somalia’s mostly private entity-driven economic environment, Ethiopia's economy is framed by a systemic state-led Growth and Transformation Plan, under the new collective leadership following former Prime Minister Asres’ death. The government is already devoting a very high share of its budget to pro-poor programs and investments, and its centralized, top-down model, has made significant progress over the past two years. The government’s restriction on foreign investment in major industries has also kept large parts of the economy closed to global trade and investment. This approach has significantly impacted the EthERNet’s approach to foreign firms, local content development, and partnerships with international institutions and ICT industry players.

21 See: http://www.ubuntunet.net/ethernet; Interview with Zelalem Asefa, EtherRENt CEO, October 20, 2015.
24 See: http://www.heritage.org/index/country/ethiopia.
Somalia’s NREN, SomaliREN, joined the research and education network community in 2009. The NREN has been founded by nine founding member universities with the help of the Royal Institute of Technology (KTH) and diaspora members from Sweden who saw the REN as a potential solution to some of the challenges facing higher education – namely the lack of sufficient connectivity for education and access to qualified lecturers in the areas of medicine, engineering and science. The telecom industry in Somalia has been hailed as a good example of how the private sector has made great gains in the country even as the public sector still works to establish its systems and processes. The prevalence and success of private entities, both those run by diaspora returnees and those emerging locally is one of the main reasons for the private, non-profit model of SomaliREN governance, though future support from the federal and regional level government administrations would be well received.

To date, lack of financial support from the government and the inability of member institutions to cover the upfront fixed costs of an advanced purchase for bandwidth has kept the SomaliREN from participating fully in the AfricaConnect parallel financing scheme necessary for connecting to UbuntuNet, the regional REN network for Southern and Eastern Africa. Nevertheless, NREN membership has grown despite the lack of an operational communications infrastructure. In the absence of an actual network, SomaliREN has worked to remain active and has been involved with small, stand-alone ICT-based capacity building projects of varying degrees of success through international partnerships with the EU, UNDP, the Turkish government, and the Royal Institute of Technology, Sweden (KTH).25

International fibre connectivity bequeathed via the arrival of the EASy submarine cable in Mogadishu during the first quarter of 2014 has radically improved Somalia’s operating environment, including bringing down the price of bandwidth. This development will make it far more feasible to establish REN infrastructure in the future. At the moment, however, with the REN infrastructure still forthcoming, universities have limited Internet connectivity, where most are able to use it only for administrative purposes, with students left to find Internet access outside the institution, typically at cyber cafes. Finally, bandwidth costs remain high in the south central parts of the country where coverage of the ISPs is limited and many organizations still depend on VSAT technology for connectivity.

**Ethiopia’s context—the NREN as a tool spanning the urban-rural divide and promoting national content development**

Currently operating on a USD$70 million budget, funded entirely by the Ethiopian government, EthERNET is operating as a second, alternative, internet service provider, beyond the Ethiopian Telecommunications Corporation (ETC) catering research and higher education institutions, and offering services to 36 universities within the public university system. Since its inception in 2001, the NREN has undergone two evolutionary changes particularly notable for this research.

**Centralized Governance Model Still Catering to Member Demand**

Over the last decade, the member institutions associated with the NREN have developed an ICT Directorate Forum, which meets quarterly and is comprised of one key individual within

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25 See: Mogadishu University interviews, October 29, 2015.
each member institution. This individual is typically the head of the IT, computer science, or computer engineering department, an identified as the university’s ICT Director and NREN representative. Though the NREN began as a centralized organization that only nominally able to accommodate input from member institutions, the Directorate has become the synthesizing forum from which member university-level needs and demands are now collated and presented to the Ministry of Education. The directorate is now the source from which all NREN decision-making on network infrastructure maintenance, ongoing development, and network related training has emerged, so long as it falls within the general auspices of centralized education policy. While the overall Ethiopian model for NREN development is highly top down and managed through the Ministry of Education, the ICT directorate’s consultative model within the overall centralized structure helps allocate the NREN funding to where it is more needed. In addition, while the NREN’s close association to the central government helps streamline partnerships with international corporate players such as Microsoft, IBM, Oracle, and CISCO, the ICT directorate’s role as conduit has helped the private sector firm’s cater training programs to fit institutions’ needs and transfer skill training to universities too rural to receive direct training. Finally, particularly as the REN network has reached more and more rural universities over the last few years, training dissemination for staff at more isolated institutions have happened partly with the help of the VC facilities enabled by the REN.

NREN Support for Local Content Development—Interconnectivity and Communities of Practice

A second major evolution within the EthERNet system has been the move towards local content development for all value added services (VAS) offered via the REN. Now that most of the physical infrastructure linking universities to the REN network is complete, institutions are focusing on developing programs for administration applications, human resource management and recruitment applications, student evaluation programs, more sophisticated data collection and housing platform, and an increasingly developing digital library, all of which member universities should be able to access via the REN network. The biggest evolution within this process has been a steady move to develop these applications from scratch rather than commissioning them from foreign firms. The first VAS application, a student progress assessment program, was externally commissioned to an international firm. However, when university administrations needed to go through the foreign firm for all adjustments necessary to accommodate changes in national level regulations, frustration over the universities’ lack of ownership over the program grew. A unanimous decision was finally taken to end the contract and transfer control over local content and application development directly to Ethiopian universities.

While not all universities had the capacity to develop such program, four universities, in including Jimma University, developed their own platforms, initially with the support of a technical capacity building partnership between Jimma University and Ghent University of Belgium and the Belgian organization, VLIR-UOS. Universities who had developed their

26 See: Interview with Zelalem Asefa, CEO of EthERNet, 10.20.2015
27 While there is also a strong argument within the REN community for NRENs to be largely independent of national government, for the purpose of this research, case analysis has looked specifically at Ethiopia’s contexts and is based on the sentiments of the individuals interviewed.
28 See: Interview with Zelalem Asefa, CEO of EthERNet, 10.20.2015.
own platforms then worked with other, less endowed institutions to customize and then share the application. The recipient universities then had the choice to partner with the platform hosting universities to train their own staff on program maintenance or to rely on the host universities for support.\textsuperscript{30}

**Spanning the Rural-Urban Divide—NREN support for ubiquitous communication links and national institutional development**

Of the various stumbling blocks faced by the EthERNet over its tenure, interviewees repeatedly highlighted last mile connectivity to rural universities as one of the greatest challenges. As part of the push to address this gap, EtherNET has asked all member universities to contribute funding to a pooled “pot” allocated towards supporting connectivity to the most under-resourced institutions. While network maintenance, support, and quality of human capacity are also major challenges facing rural universities within the network, expansion of the physical Network infrastructure as served as a significant tool enabling Ethiopia to more equitably distribute training and resources to the higher education sector across rural-urban divide.

Masters degree partnerships between Ethiopian universities and India’s National Indian Institute of Technology (NIIT) campuses offset technology and curriculum gaps within Ethiopian institutions via video conference (VC) technology and distance learning programs. In addition, similar resource sharing is beginning between urban and rural institutions in Ethiopia. Over the last several years, new initiatives building on the EthERNet network are starting to mitigate the rural universities’ typically far weaker skillset amongst faculty members and underequipped laboratories, in comparison to their rural counterparts. While still in process, plans are in place to use the EthERNet Network Operating Center (NOC) and Data Center to share access to high performance computing resources present at certain universities but absent in others, and pool research findings from various STEM professions across the network.\textsuperscript{31} Similarly, an ongoing digital library project currently housing over 6,000 books virtual books housed within the EthERNet’s Data Center further supplements the technological and human resource gaps within rural universities.\textsuperscript{32} Though the Ethiopian higher education sector has identified a shortage of printed books within the country, the digital library and access to databases and library of international and regional institutions connected via the EthERNet, its connection to UbuntuNet, and now GEANT, has grown the scope of all institutions along the network.

Similarly, Train the Trainer programs supporting network engineers and building capacity of university lecturers are also increasingly able to operate within national institutions without having to rely on knowledge transfer partnerships taking place outside the country.\textsuperscript{33} Though capacity building programs are still far from being based entirely in Ethiopia, the higher education sector is interested in keeping skill development as local as possible. The aim is to enable institutional development to grow along with human resource capacity supporting the overall technical capabilities within the country. While not a silver bullet, the NREN’s network infrastructure and social network of national and regional REN members has acted as an important enabler for localizing training to the extent it has developed thus far. Ethiopia’s NREN experience demonstrates some of the impact such a network can have on national technical capacity development in fragile and emerging economies, as well as hinting towards the potential gains that still lie ahead.

\textsuperscript{30} See: Interview with Girum Ketema, ICT Director, Jimma University; 11.07.2015.

\textsuperscript{31} Ibid.

\textsuperscript{32} See: Interview with Yonas Mekonnen, System Administrator, EthERNet, 11.08.2015.

\textsuperscript{33} Ibid.
Somalia’s context—the NREN as a source of common ground

Somali universities interviewed for this project have suggested that there is a growing interest within Somali research and education institutions in the role ICTs can play within the sector. However, a general lack of technical capacity and awareness of how ICTs can be used has kept this role under-developed. At some universities, there is no clear concept of what a NOC is and how it can best be used to expand the service offerings of an NREN network. This is the case partly because there is little firsthand experience of NREN networking within the national higher education faculty and administration pool. A common lack of understanding of the role ICTs can play within the university other also keeps university-level investments in communication technologies low. Yet even amid these operating environment constraints, some universities have a dedicated server room, which includes a rack with a server that is designed to host a student information system and a digital library. Other universities, such as SIMAD University in Mogadishu, have appointed a Head of IT who reports to the Director for Institutional Development of the university and helps streamline ICT infrastructure within administrative systems and classroom curricula. Interviews suggest that the awareness of how communication technology can impact quality of education within institutions and the overall national skillset has grown. However, because Internet use is mostly limited to email communications, instant messaging, web browsing and Internet search engine use, even within universities that are considered well resourced, awareness of the extent to which communications infrastructure can augment higher education and research capacity is limited.

Standardizing systems and visions for the future—the NREN as a catalyst for a sector-wide ICT strategy

Amidst these challenges, the findings of this research suggest that, once operational, the Somalia NREN’s physical network infrastructure and connections to other member institutions can act as a conduit for human resources capacity building, particularly within the Somali context. Somali higher education institutions that are members of the NREN have in the past benefited from capacity building efforts funded by the EU and other donors, and facilitated by Kenyan universities as twinning partners. The NREN has also been a source of common ground between member institutions that has made it possible for to share the knowledge created from international partnerships with certain universities across other institutions. In addition, the NREN has created a number of cross-border partnerships and opportunities that have served both sides well. For example, local universities have engaged the services of their foreign partner universities in developing curriculums and conducting curriculum reviews.

The NREN as a Facilitator and Organizer of Capacity Building Initiatives

Despite the fact that there is still no connectivity infrastructure in place, the SomaliREN’s outward facing role has already served as an intermediary body linking Somali universities and international institutions through learning and training initiatives. Though it has not been able to capitalize on the fibre-optic network of a typical NREN, it has already facilitated trainings its connection to the UbuntuNet Alliance helped initiate. Though these are still stand-alone initiatives without the scope of a national project, some universities have

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34 See: Interview with Mogadishu University stakeholders, 10.29.2015.
received knowledge and skills in the areas of management, curriculum development and ICTs thanks to these connections. In this sense, the NREN has played a small-scale role as a coordinator of the capacity building initiatives. This hints of what could come should the physical REN infrastructure would be deployed. Similarly, its impact could have been multiplied, had the higher education sector developed a unified strategy for the NREN to contribute to building the country’s human resources capacity.

As a conduit, the NREN could also connect the Somali higher education institutions and the private sector to facilitate the transfer of knowledge as well as assist in the creation of new skills or innovative ways to apply existing skills. Currently, many of the universities in Somalia are employing expat professors and lecturers to supplement the shortage of qualified skilled educators in the areas of engineering and the sciences. Other institutions are partnering with foreign (mostly Open Universities) to offer distance learning postgraduate programs. These programs usually require local facilitators to guide the students and help grade their work before submission to the foreign partner. In many instances, shortages of lecturers in certain disciplines, or security constraints limiting instructors’ physical presence, result in the university assigning potentially under qualified lecturers with little consideration for the instructor’s actual capability. The NREN could play a significant role in filling these gaps by providing live-streaming video-conferencing lectures by the actual course instructor and there would be no need for a local facilitator.

Although these forms of knowledge transfer and capacity development focus on academic institutional development, they facilitate a sharing and exchange of ideas and best practices which can impact the ICT sector and the medical and science professions in which Somali post-graduates would ideally eventually be employed. Interviews with the ICT directors at two universities showed that the biggest driver of ICT capacity building in their institutions were the partnership agreements and collaborations they made with their foreign counterparts. The provision of video-conferencing facilities in the universities is seen as a cost-effective means to access qualified instructors and improve inter-university collaborations, making the most of the MoUs signed in partnership with many foreign universities.

**The NREN Building Out Institutional Capacity**

Interviewees have reiterated the sentiment that the universities in Somalia are well-positioned to multiply the reach and scope of capacity building initiatives where the NREN could play the role of the coordinator and organizer of capacity building activities. For this to succeed there should be a common understanding of the existing knowledge gaps that inhibit national growth and development. It is also pertinent to have a standardized assessment of technical and human capacities to identify the gaps that need to be addressed by the capacity building efforts.

The approach that has been echoed by the ICT directors and institutional development directors of the universities interviewed for this research is to create a network of trainers across the member institutions of the NREN that will be accountable to the NREN in carrying out the mandate of training other trainers to extend the reach of any human capacity building program to have the required multiplicative effect of the skills to be created or developed.36

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35 See: Interview with Kismayo and Golis University stakeholders, 11.06.2015.
36 See: Interview with Kismayo University stakeholder, 11.08.2015.
Sentiments from the ground seem to be pushing for capacity building initiatives based on an officially recognized, crosscutting, and ideally national-level strategy, based on standardized assessments. The NREN could potentially play a role bringing together policy makers and education institutions to develop such a unified human resource development strategy in the case where government leadership is not making such a push. Potentially using its independent, non-profit status as an advantage, as it continues to develop, SomaliREN could follow the lead of the private sector actors in the Somali economy and provide support to both the ICT sector and the higher education sector in areas where the government is still weak.

**Conclusion**

In addition to a REN’s primary mandate to provide connectivity for the higher education sector, this paper explores some of the underlying contributions that a national Research and Education Network can provide to a country’s economic development – specifically human resource capacity in the technology and technical fields. Taking a comparative view of Somalia and Ethiopia’s NREN experience thus far, this research inquiry identifies the NREN’s ability to facilitate a sector wide ICT capacity building strategy for higher education and research institutes, national and international university partnerships for distance learning and exchange program-based training programs, and train the trainer programs on ICT infrastructure maintenance and VAS development within national institutions as key areas where it can support national level human resource capacity growth.

Newly developing NRENs, particularly those at Level 3 of the NREN Maturity Model as proposed by Duncan Greaves, former CEO of TENET, South Africa’s NREN, often face challenges with having their member institutions understand how research and education networking can be best be used to maximize its potential. The NREN experience in Somalia suggests that a vaguely defined NREN sometimes generates varied, and at times, unrealistic expectations from the members as to what value NREN membership may provide their respective institution. Again, the Somalia context, an example of NREN development in its early stages, and the Ethiopia context as a more mature NREN where great effort has gone into bringing infrastructure to isolated, rural areas, both demonstrate how this lack of clarity can develop in part through the NREN’s marketing at project inception. In both cases, the rationale of establishing the NREN focuses on the value for money argument where the Network would provide more affordable bandwidth than otherwise available by through demand aggregation and leveraging member institutions’ collective purchasing power. Given the challenge of laying and maintaining first-mover fibre-optic communication infrastructure, priority is often given to basic infrastructure development and last-mile reach, while knowledge transfer and training programs and value added services building on the bandwidth provision get less attention. Even once the infrastructure is in place, lack of awareness raising and technical skill development at the university level and within the NREN administrative organization can result in the research and education network being underutilized. Yet while it needs its own set of capacity programs to function effectively, the NREN can play as a coordinator and facilitator for this and other national-level skill training and knowledge transfer initiatives. Ethiopia’s EtherNET and Somalia’s SomaliREN have been able to facilitate these activities to varying degrees in their respective contexts to varying degrees, with their methods of

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operation and organizational structure being in part a function of the environments in which they operate.

Moving forward, Somalia’s experience demonstrates that an NREN can build communities of practice along with, and even prior to its work implementing the physical infrastructure. Ethiopia’s experience involving university-based ICT directors in key decision-making demonstrates how both government-led and private entity-driven NREN governance models can effectively incorporate member interests and concerns. As the NRENs in both countries continue to expand in different ways, it might be prudent to consider how some of the value added services that make an NREN so unique can be utilized by universities to better support the development of a domestic skilled talent pool.

One option, of many, is to offer NREN capabilities as a consultative service, which could generate additional revenue streams to be reinvested back to support the project’s sustainability. In the interspace linking the higher education and ICT sectors, the NREN’s organizational structure and network-based value-added services can act as source of common ground and mutual gain-driven collaboration member institutions. Particularly in the context of recently fragile or post-conflict states, the cases looked at for this inquiry shed light on how an NREN can be used to grow research and education and technology-based ecosystems growing the ability of local populations to populate and sustain their countries’ economy long-term.

**Biography**

Rachel Firestone is working with the World Bank Group on ICT policies and applications, particularly in the contexts of fragility and conflict. Rachel works on ICT projects that use innovation and broadband infrastructure as tools to accelerate economic development process and improve partnership and transparency between governments, academia, the private sector, and grassroots communities. Prior to coming to the World Bank, Rachel completed her Masters at Georgetown University’s Masters of Science in Foreign Service program, in the Global Politics and Security, focusing on community resilience and post-conflict reconstruction. Prior to working in East Africa, Rachel also spent five years in India working on using ICTs and multi-stakeholder partnerships to support social inclusion and self-advocacy initiatives with communities recovering from sectarian violence and internal displacement. When she is not working with tech hubs and academic institutions on cross-sector learning and collaboration, Rachel enjoys climbing, running, and cooking very spicy meals.
Experts’ Assignment Algorithm for Cloud-based Agro-advisory Service Information System (CASIS) using Weighted Sum Model: Piloting CASIS

K Kadeghe G. FUE1*, S.D. TUMBO2, and C.A.SANGA
Sokoine University of Agriculture
1Centre for ICT, 2Department of Agricultural Engineering and Land Planning, 3Department of Informatics,
*Corresponding author: kadefue@suanet.ac.tz

Abstract

A Cloud-based Agro-advisory Service Information System (CASIS) uses interactive operating mode where assignment of questions from farmers to experts is done manually. Questions as input to the system are received randomly in a day and experts are supposed to respond within a specified time. The system has 20 experts in its database who respond to farmers questions and it can receive more than 30 questions per day. If there is a significant delay in the responses to a question then the question is reassigned to another expert. Each expert behaves differently when responding to their assigned questions. In order to address the shortcomings, the experts’ assignment algorithm was developed utilizing the respondents’ response probabilities and time of responses. Assignment decision is based on using a model that trains ‘CASIS’ on the determination of best experts. CASIS training algorithm is developed to complement current weakness. The algorithm doesn’t omit experts who respond late but complements them with active ones. The decision boundary is homogeneity and numerical so as to give a single output quickly. The input (x1, x2) and output (y) variables are numeric. The main concept is that the output is generated using linear combination or weighted sum model. The algorithm considers response time as best criteria to satisfy the farmers who send the questions. This algorithm provides a great chance of finding a quick answer within a short period of time. Automatic expert assignment is essential to achieve high adoption of the system that satisfies the on-time farmer advisories demand and promote efficiency as well as effective extension services for rural development.

Keywords: cloud-based, information system, extension, agro-advisory service, expert, CASIS

Background

The agricultural sector is one of the important drivers of many African countries’ economies. The sector contributes nearly 30% of the continents Gross Domestic Product (GDP) and 70% of the continent’s population depends on agriculture to sustain their life (WB, 2015). According to World Bank, agriculture is an important asset for achieving the Millennium
Development Goals (MDG) and a means to reduce poverty in sub-Saharan Africa (WB, 2011; WB, 2015). In Tanzania, more than 80% of population living in rural areas heavily depends on agricultural activities to earn their living (World Bank, 2011; WB, 2015). In 2003, agriculture accounted for half of the country’s GDP, provided 51% of foreign exchange and employed 80% of the labour force. It accounts for half of the country’s total GDP (World Bank, 2011; FAO/MAFAP, 2013; World Bank, 2015).

The agricultural sector in Tanzania is facing so many challenges that prevent its prosperity. Among the challenges that hinders the agricultural sector is ineffective agricultural extension services. Farmers have limited access appropriate information in space and time (Sanga et al., 2014b). The Government of Tanzania has come up with different policies that address problems in agriculture sector. An example of such policy is the ‘Kilimo Kwanza’ Declaration (Agriculture First Declaration). ‘Kilimo Kwanza’ aimed at igniting the agriculture sector by emphasizing applying modern techniques of farming (URT, 2010). The Government has installed optical fiber across the country and it is now encouraging citizens to use different ICT-based services. Examples of ICT based services are mobile payment and agro-advisory services (i.e. Tigo Kilimo, Voda Club, Z- Kilimo, M-Pesa). The use of modern telecommunications services and ICT to support farmers has been studied broadly by various scholars (Gakuru et al., 2009; Sanga et al., 2013a; Sanga et al., 2013b; Sanga et al., 2014a; Sanga et al., 2014b; Pongnumkul et al., 2015). ICT has potential to facilitate quick access to information and relevant knowledge that may improve agricultural productivity, reduce poverty and ensure food security in developing countries (ITU, 2009). Use of mobile phones provides the next digital stage of providing extension education and service to the farmers remotely (Gakuru et al., 2009; Sanga et al., 2014a; Pongnumkul et al., 2015).

Zerfu et al. (2011) reported that among the various problems cited for the poor performance and low productivity of African agriculture is the ineffectiveness of the agricultural advisory services. Neglect of agricultural extension systems in several African countries in the last two decades has resulted in declining agricultural productivity (World Bank, 2015). Despite the initiatives which have been made to understand the organizational and capacity issues that confront effective design and implementation of agricultural advisory services there is still a need to evaluated their impact in terms of efficiency and effectiveness (Sanga et al., 2014b).

The adoption of new technologies in agriculture depends on two important factors, namely: user’s own benefit analysis i.e. how the user perceives the technology and how much value does it have. The other important factor is the seriousness of the national programme or on the national legislation e.g. incentive to adopt it or punitive actions to ignore it (Hall & Khan, 2003). Most farmers in Kilosa district, in Tanzania perceive Cloud-based Agro-advisory Service Information System (CASIS) as an alternative advisory agent that provides useful agricultural information. In order to complement the conventional agricultural extension services in Kilosa District, SUA through a project under EPINAV (Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value-chains) embarked on improving coverage of extension services through the use of mobile based CASIS. CASIS utilize the strength of ICT to deliver advisory information and knowledge to the farmers. CASIS consist of web-based agricultural knowledge and information system (WAKI) and mobile-based agricultural knowledge and information system (MAKI). The first version of CASIS required the farmers to pay for all the SMS that they sent to the system and the system had very few participants. The second version of CASIS allows utilizing the mobile bundles that the farmers use to send free SMS for agro-advisory service. This version is very attractive and thus, it is used by many farmers in Kilosa District and some Districts of other regions in Tanzania.
The system also keeps record of all questions and their answers. Mobile based AAIS is the SMS based version of the web based CASIS. The farmers and extension agents can communicate without knowing each other. The farmer can send SMS using a specific dedicated number. After that, the control unit assigns a specific expert to answer the question. The expert will be notified by the system and respond by answering. Just after submitting the answer, automatically it is sent to the farmer. The farmer will see the answer using different means such as e-mail, web and mobile phones. The controller can also view and see the questions and corresponding answers and know who has answered the farmer.

Experiences and Challenges of CASIS

Weighted sum model algorithm

Automatic assignments of questions require that the system calculates the numbers of questions to be answered and the number of available experts to answer. It calculates using the WSM. This involves modeling the expert's response time and number of questions he/she has provided to the system. The request and response time is very important when responding to farmers questions. When the answer takes a lot of time then farmers tend to complain. This is always solved if the question is assigned to another expert who is going to respond very fast. The period under which the question has not been answered is called ‘lapsing time’. The time at which the farmer's question is received to the system is called ‘question time’ while the time at which the farmer gets answer is called ‘response time’. It could be noted that ‘lapsing time’ is the difference between the ‘question time’ and ‘response time’. There is a delay when packets containing the answer move from the expert to the farmer. For modern technologies, this could be estimated to negligible.

It should be noted that the ‘lapsing time’ should be very small to account for best performance of advisory system. When it is increasing then the system acceptability is at stake. The greater the ‘lapsing time’ the less the system is going to be accepted by the farmers and other agricultural stakeholders.

The decision boundary (lapsing time) is homogeneity and numerical so as to give a single output quickly. The input (x1, x2) and output (y) variables are numeric. The main concept is that the output is generated using linear combination or WSM using the given set of inputs \( y = p_1x_1 + p_2x_2 \) where \( p_1 \) and \( p_2 \) are cumulative weighted probability of responding to questions. Probability adjustable as the expert answers the questions per week or per weekend. \( p \) is calculated using number of answers received against number of questions assigned. The algorithm considers response time as best criteria to satisfy the farmers who send the questions. \( x_1 \) (on workdays) and \( x_2 \) (on weekends) are determined using cumulative average answer wait minutes where scale is 1 to 40 where 1 represent 40 minutes and 40 represent 1 minute wait. \( p_1 \) represents probability of questions answered within 40 minutes wait time for a period of last 5 workdays. \( p_2 \) represents probability of questions answered within 40 minutes wait time for a period of last 2 weekends. Most experts don't respond to questions in weekends but this algorithm counts the points of weekend too when determining the best ones. In weekend days, the decision boundary can only be determined using \( y = p_2x_2 \) where \( p_1x_1 \) is considered as null decision variable when \( y = p_1x_1 + p_2x_2 \) can't give final decision. Table 1 shows the simulated data from the CASIS for six experts.
Table 5: The CASIS simulated data using WSM

The simulated data provides demonstrative example of the WSM. The best performer in this case study is expert F. He has accumulated a 35.66 WSM while the worst performer is expert B with 15.87 WSM. In order to achieve the maximum of 80 WSM, the experts will be required to provide answers within the shortest period of time (less than 1 minute) and answer all the questions that were assigned to them. This is quite challenging to our experts in Kilosa since they are providing free advisory service without any incentives.

WSM provides a fast decision output that could be fed to the system. It is likely that the WSM provide the same output every time. The random selection among the best performers is necessary. Also, random selection can be used to increase the total points of the weaker respondents. It is unlikely that the decision will be biased to the best performers. This means the system will try to lower the loads of the best performers by involving other individuals who may provide answers too. The lowest performer will be changing regularly, thus the system involves everyone in the group of those offering advisory so that each can get WSM points to be involved more in future.

The model was provided with data from the database where the live questions are to be fed to the model for decisions. The algorithm fetches the information from the database of our AAIS and determines the ‘lapsing time’ for each expert and then calculates the output.

This weighted model has provided an alternative to human being manual way of assigning questions and creates a room where biasness is avoided to increase efficiency of the system. The behavior of the extension officers toward answering advisory service through their mobile phones has dramatically changed and some have not changed (i.e. constant behavior). This algorithm is expected to provide best solutions to farmers without being concerned with the experts who provides answers.

Results and Discussion

The number of answered questions increases the points or credits to the best performers but it can be relying more on ‘lapsing time’. ‘Lapsing time’ of many questions is the average of ‘lapsing time’ of the week or month. Using week ‘lapsing time’ provides new data of the best performers. It means that the best performers of the current week can change dramatically. The worst performer could be incorporated to the new week. This looks like a moving average but with restrictions of the number of data. There is no specific week where the system can determine the best performer but it is the daily process where best performers are calculated.

Referring to Table 1, the expert who seems to be very fast in answering has not reached 40 WSM which is half of the maximum required. This shows that the algorithm was well simulated. In real sense, the extension agents in the database have not been answering questions within the 40 minutes of the assignment or lapsing time. In the database only 11%
of the questions were answered in period of 40 minutes. This is due to manual reassignment of the question which is difficult and the experts are not well motivated to provide fast response. In this model, the x1 or x2 can be adjusted to 50 or 60 minutes depending on satisfaction of the farmers.

**Conclusion**

This algorithm has provided the best solution to the manual assignment. The weakest point of the algorithm is that it can be biased to some individuals especially when the ‘lapsing time’ of the worst performers is very large. In order to get faster response then the efficiency of the algorithm is likely to avoid underperforming individuals. It is quite acceptable if the system performs wonderful automated assignment without giving burden to few best performers. The best performers should be compensated to their salaries so as to increase the morale to work hard. It is recommended that in future, we need to do a survey to farmers to ask them on the appropriate value of x (lapsing period) that they can wait for answer and then readjust the algorithm coefficient (x1 and x2) accordingly.

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**Biography**

Kadeghe Fue received his M.Sc degree from the University of Florida, USA in the summer of 2014. He studied precision agriculture, information systems and automation. He holds B.Sc(Hons) in computer engineering and information technology from the University of Dar es Salaam, Tanzania. He joined Sokoine University of Agriculture in October, 2011 as the member of academic staff. Kadeghe holds several awards received since 2004. Recently, He received the Pan African Conference on Science, Computing and Telecommunications (PACT) 2014 best student paper award in Arusha, Tanzania. Also, he received Borlaug LEAP fellowship award in the fall 2013. He is a graduate engineer member of the Institution of Engineers Tanzania since 2011 and American Society of Agricultural and Biological Engineers since 2013. He has specialized in applications of computers and electronics in Agriculture especially in area of Precision agriculture, e-agriculture and Software systems engineering. He has published several scientific papers in ICT for Development and applications of electronics
in Agriculture. Also, He does consultancy in software systems development and electronic control systems development to the public and private companies. For more details visit his page http://www.cict.suanet.ac.tz/kadefue/
The Making of MoRENet

Robert JANZ\textsuperscript{1}, Lourino CHEMANE\textsuperscript{2,3}

\textsuperscript{1}Centre for Information Technology, University of Groningen, P.O. B. 11044, 9700 CA Groningen, The Netherlands
Tel: + 31 503639200, Fax: + 31 503633406, Email: r.f.janz@rug.nl

\textsuperscript{2}Ministry of Science and Technology, Higher and Technical Education, Av. Patrice Lumumba, 770, Maputo, Mozambique
Tel: + 258 823110700, Fax: + 25821352860, Email: lourino.chemane@mctestp.gov.mz

\textsuperscript{3}Department of Electrical and Electronic Engineering, Faculty of Engineering, Eduardo Mondlane University, Av. De Moçambique, Km 1,5, Maputo, Mozambique
Tel: + 258 823110700, Fax: + 25821352860, Email:lourino.chemane@mctestp.gov.mz

Abstract

Although MoRENet has been defined in 2002 and included in the National ICT Policy Implementation Strategy of Mozambique as one of the priority projects in the area of education, only in in 2005 the pilot phase of this network started covering some institutions in Maputo, and it took until 2014 before MoRENet started to provide national services. The reasons for this long gestation period and how they were dealt with can be lessons for other emerging National Research and Education Networks (NRENs). The discussion of MoRENet initiative started during the formulation of the ICT Policy Implementation Strategy in 2001, and it has been defined as a project with the aim of providing affordable Internet services for the Higher Education and Research sector in Mozambique. The first attempt to build a national network for research and higher education and implement the envisaged services in Mozambique did not take off for various reasons, the most important being that the initiative was not well embedded within the stakeholders and also because there was no sound financial plan. NRENs are often presented as a technical solution to provide affordable Internet services, with the higher education and research sector as sole beneficiary. It is wiser to address society priorities related to the Networked Readiness of the country when trying to prove the case of the NREN. In 2011 the MoRENet initiative got back to the momentum it had in 2005, this time as a joint project of the Ministry of Science and Technology and the Ministry of Education and Culture. At the end of 2012 a financial plan was presented that forecast that, with initial funding from the World Bank, through the Mozambique eGovernment and Communication Infrastructure Project (MEGCIP), MoRENet would be financial sustainable in 2016. Since 2014 MoRENet is providing services and in 2015 has reached national coverage.

Keywords
NREN, MoRENet, Business Model, Research and Education, Connectivity, Internet Services.


The Mozambique Research and Education Network (MoRENet) is perhaps one of the oldest National Research and Education Network (NREN) in sub-Saharan Africa: it has been defined in the Mozambique ICT Policy Implementation Strategy approved by the Council of Ministers of the Government of Mozambique in 2002 (Council of Ministers, 2002) and its
pilot phase was established in 2005 covering 12 institutions in Maputo, and together with the UbuntuNet Alliance can celebrate its 10\textsuperscript{th} anniversary this year.

In 2005 the Higher Education and Research domain in Mozambique were under different government departments, the Ministry of Education and Culture and the Ministry of Science and Technology respectively, with challenges in terms of collaboration and knowledge exchange between institutions. The higher education and research institutions were also facing difficulties in accessing international data communications resources, and some institutions were accessing the Internet through VSAT with high bandwidth costs. There was also some institutional challenges in implementation the strategic ICT vision defined in 2000 at the national ICT Policy (Council of Ministers, 2000), and operationalized in 2002 through the ICT Policy Implementation Strategy(Council of Ministers, 2002) , as well as the lack of strategic vision in adopting ICT at the institutional level.

It was in this environment that the Ministry of Science and Technology took up its responsibilities and established MoRENet in 2005. The objective of MoRENet was to integrate the national research and academic institutions into one national broadband network and to offer high quality data communication services for the participating institutions. The MoRENet strategy and service portfolio was presented, there was a proposal for the network architecture and there was an implementation plan (divided into three stages) and a governance model.

In short all the ingredients of a professional business model were in place to enable a successful launch of MoRENet operations in the 2006 – 2007 time frame. In reality the process came to a stand still shortly after the presentation of the business model. What happened?


As is often the case there is no single cause for this fall back, but more a combination of events and circumstances. The most important in the case of MoRENet are the following:

1. The approval of the ICT Policy Implementation Strategy in 2002 by the Government of Mozambique was followed by the challenge of establishing new government structures to coordinate and manage the implementation of this strategy (Council of Ministers, 2002) . The ICT Policy Implementation Technical Unit (UTICT) has been establishing for this purpose but it focused in eGovernment-related priority projects...
and the education-related priority projects were left to the specific line ministries, Ministry of Education and Ministry of Higher Education Science and Technology.

2. With the creation of the Ministry of Science and Technology in 2005 the government responsibility over the academic (research and education) and ICT sectors were spread out over two ministries, namely “Science and Technology” and “Education and Culture”. In any political system this will lead to political and bureaucratic challenges necessary to coordinate and lead the implementation of a transversal initiative such as the MoRENet, dealing with technology aspects but also with research and education processes and systems. The priority of the Ministry of Education and Culture in this period was focussed on improving primary education and secondary to overcome the huge illiteracy rate in Mozambique, and on reforming the Higher Education sector.

3. The MoRENet initiative had been spread out over the Mozambican academic community as a warm blanket with the prospect that everything would be better if the plans were to be implemented, but without a sense of ownership by the academic community. As with the Higher Education sector within the Ministry of Education and Culture the MoRENet initiative had to compete with other challenges that often had a higher priority than a national data communication network for Higher Education and Research.

4. The Government of Mozambique has not secured funding for all the priority projects that were part of the ICT Policy Implementation Strategy, including MoRENet.

5. In this period the telecom market in Mozambique was dominated by the national telecom operator, TDM, without any competition from commercial telecom operators for broadband services (Council of Ministers, 2007). Mozambique is geographically a large country (more that 3000 km from North to South) with the economic, technological (concentration of telecommunications operators and ISPs) and political decision centres in Maputo, the capital city. Without affordable bandwidth to academic Points of Presence in the provincial capitals and districts it was practically impossible to create the physical national MoRENet network.

In 2007 and the following years some MoRENet infrastructure, as well as a radio linked network, was installed in Maputo to interconnect 12 institutions using a TDM backbone, but the national network organisation (MoRNet institutionalisation) that was to provide advanced services for its member did not materialise.

There are several lessons learned from this unfortunate start of MoRENet. First of all, it was deadly that the member constituency was not involved from the beginning. As a result there was no sense of ownership of the project by the leadership of higher education and research institutions in Mozambique. A consequence of the lack of ownership was further that there wasn’t a strong leader to take over from the beneficiary institutions and that was left to the Ministry of Science and Technology. Second, there was no sound financial plan, in terms of expenditures and revenues, to support the MoRENet business model. The prospect that the connectivity tariffs would come down if MoRENet became operational was in itself a valid assumption, but it should have been validated with a sound financial plan. Third the government support was missing. Having two ministries involved in the process was in itself

38 In a personal communication with Minister of Science and Technology in 2005, Minister Honourable Prof. Doctor Eng. Venâncio Massingue, he used as example that the need to develop knowledge and skills to prevent the many deaths per year by the annual flooding of the Zambezi basin was much more important for Mozambique that developing MoRENet.
of course challenging, with political, bureaucratic and personal hurdles that had to be taken. Because the two ministries could not form one front, MoRENet did not emerge to the level of national policy attention. Government support at the highest level is essential for the sustainability of any NREN and Mozambique is no exception. This support needn’t always to be in terms of financial resources, in the case of MoRENet government could have negotiated with TDM to offer affordable tariffs for the national connectivity or other compensatory mechanisms. Finally, MoRENet was presented as a technical project with the Higher Education and Research sector as sole beneficiary. The initiative was not linked to the necessity to transform the higher education sector as part of the information or knowledge society approach frameworks, although it was a priority project of the ICT Policy Implementation Strategy intended to contribute in building the information society in Mozambique (Council of Ministers, 2000, 2002, UNDESA, 2005).

In short: MoRENet was not embedded in in the Higher Education and Research institutions and lacked a financial plan. By no means is this resumé meant as criticism of the efforts of the Government of Mozambique, in particular the Ministry of Science and Technology. The Government of Mozambique had the vision that Mozambique needed an NREN, as indicated in its ICT Policy (Council of Ministers 2000), and that the NREN should be part of a regional network of NRENs, there was a MoRENet business model (even though the financial chapter was missing) and the leadership of the Ministry of Science and Technology was enthusiastic advocates of the MoRENet. Without the involvement and leadership of the Ministry of Science and Technology there would be no MoRENet today!

3. Network Readiness

That ICT is the driving force in the transformation to the Knowledge society is not disputed, as well as the fact that the path to the Knowledge Society is the only way to economic development and a sustainable society. But the role of NRENs in this process should be emphasized more. Since 2005 the Network Readiness Index (NRI) of more than 120 countries has been monitored. The NRI gives an indication of how fit a country is to deal with the transition to this Knowledge Society. The NRI is based on the assessment of 10 ICT related pillars. For example the 2015 NRI of Mozambique is 2.9 out of 7.0 maximum points (rank 129 out of 143 countries). The base values of the ten pillars are presented in Figure 2. In the context of this paper it is relevant to mention that a
strong NREN can contribute to the advancement of the pillars 3 (Infrastructure), 4 (Affordability), 5 (Skills), 6 (Individual Usage) and indirectly, by delivering ICT savvy young people to society, 7 (Business Usage). This would be some of the variable or dimensions (social outputs and impact) [6] that should have been used to argue for social and economic value of MoRENet (Chemane, L., 2010, Keeney, R., 1992, UNDESA, 2005) to build a strong argument to secure the financing of MoRENet and even to construct a scenario for the preferential treatment of this education initiative by the telecom sector. Further discussion of the NRI could be very interesting, but does not fit in the time allocated for this paper. What is important is that the NRI can be a powerful tool to prove the value of NRENs for society and should be used more often (Pale, P. 2001, Popov, O.2001,UNDESA, 2005).

For example one might want to demonstrate the relation between the quality of education and the availability of Internet in schools with the trend graph in Figure 3 (based on the real data!).

![Figure 3 Relation between Internet access in schools and Quality of Education?](image_url)

### 4. Revival of MoRENet (2011-2013)

In 2006 the Higher Education section of the Ministry of Education and Culture had started a Dutch funded project with the aim of strengthening the management capacities of Mozambican public universities. One of the work packages of the project was to develop and implement a Student Information System (SIS) for the participating Higher Education Institutions. This SIS would not only enable the institutions to efficiently and effectively manage the student information, it would also be a platform to provide the ministry with metadata about the student cohorts. Without a national network this meant that the required data was burned on CD’s and then sent per snail mail to the ministry. Also software updates of the local systems were burned on CD’s and sent to the IT departments of the institutions. This was of course not the ideal work flow, anno 2006/2007, and the conclusion was that Mozambique needed in fact a national network for Higher Education (there were of course many other reasons why this network was necessary, but the SIS was a visible demonstration of why this network is a necessity) at least from the Ministry of Education point of view.
(Weick, K., & Sutcliffe, K, 2005). The project was already several years underway before the Dutch project manager became aware that somewhere within the Ministry of Science and Technology somebody was working on a project to create a national network, namely MoRENet. This initiative was not enjoying the necessary support within the Ministry of Education and Culture.

Once the link between the Higher Education project and the MoRENet initiative had been established a bottom up approach was followed (Weick, K., & Sutcliffe, K, 2005) A short overview of the steps that were taken follows:

- The Ministry of Science and Technology has already secured World Bank funding for the MoRENet project, through the Mozambique eGovernment and Communications Infrastructure Project (MEGCIP)( World Bank 2009)on the condition that it should be used on the base of a MoRENet Business Model, including a financial plan, that proved that MoRENet would become a sustainable organisation.
- The IT departments of the public universities and the Ministry of Education and Culture were informed of the project and involved in the progress.
- The Minister of Education and Culture called for a meeting of the rectors of the public universities (with mandatory attendance).
- There was a formal meeting of the Minister of Science and Technology and the vice-Minister of Education and Culture to underline the commitment to jointly go forward with the MoRENet project.

During this period a few external events took place that were of advantage to the MoRENet initiative:

- In 2009 SEACOM, a submarine cable operator had begun to provide Internet connectivity to Mozambique through their landing point in Maputo. This increased the available Internet bandwidth in Mozambique twenty fold and as a result the tariffs dropped significantly. UEM was the first public university to profit from this when they negotiated a 15 years lease of a STM-1 (155 Mbps) circuit to Europe.
- In 2012 Movitel, the third Mobile operator in Mozambique entered the Mozambican market for mobile, fixed line and Inter services. Not only did this terminate the monopoly position of TDM on leased line services, also Movitel’s business model was very attractive for MoRENet. To avoid the fierce competition in the capital, Movitel first concentrated on rolling out telecom infrastructure to the rural areas of Mozambique and also offered to provide free Internet for schools while doing so.

5. The MoRENet Business Model

In 2012, with the help of a consultant contracted as part of the implementation of the Mozambique eGovernment and Communications Infrastructure Project (MEGCIP)[9], a MoRENet business model (Janz, R., 2013) was developed, together with a financial plan. The model has been developed in various iterations where involvement of the future member constituency was sought for guidance and ratification. In the business model all the aspects of a business model are presented ranging from the mission, the challenges that are faced, the services that will be provided, the potential customers, the organisational setup and the governance. These elements come together in the final chapter with the financial model. The summary of the subsequent chapters is as follows:

In The Case of the NREN the ambitions of MoRENet are laid down. At a global level NRENs have been identified as important vehicles in developing Knowledge Societies,
demonstrating the need of creating a similar institute in Mozambique. In the international ranking of Networked Readiness Index Mozambique is ranked as 120 (of 138) and it is demonstrated that a NREN can contribute to the improvement of this Network Readiness Index. MoRENet is to be an independent, not-for-profit organisation that will first provide affordable Internet for its user constituency and later also provide other services.

In **Mozambican Telecom Analysis** the situation with regard to the telecom situation in Mozambique is analysed. Four connectivity levels have been distinguished: the Local Network, the Last Mile, the Last Mile and International Bandwidth.

Many of the potential members are far away from the national fibre optic grid and need financial support to connect to the nearest MoRENet Point of Presence (PoP). The Last Mile challenges of all the potential members of MoRENet needs to be inventoried. The national telecom regulator, INCM, should be involved to assist in solving the Last Mile challenge.

TDM has a dominant role in providing capacity at the national level in Mozambique. The tariff structure of TDM stands in the way of setting up a sustainable MoRENet to provide its services not only in the capital Maputo, but also to the institutions that are in the provinces. The current customer-provider relation between MoRENet and TDM needs to be changed to a partnership if MoRENet is to succeed with TDM as provider. There also other providers that can act as partner for MoREnet, such as Movitel and EDM. If TDM is not willing to go into a partnership with MoREnet then discussions with these providers should be initiated.

The current contract for an STM-1 to London with SEACOM can be re-allocated for another purposes once the Africa Connect bandwidth becomes available as long term sustainability of MoRENet is best guaranteed if it makes use of the services that are to be offered by the UbuntuNet Alliance. Another option is to keep the SEACOM link as part of MoRENet as redundant international link.

In **User Analysis** an overview of the potential members of MoRENet is provided. It is observed that the HEI sector is not yet involved at the strategic level of the MoRENet development. As the HEI sector will prove to be the motor to reach a sustainable situation this situation has to be changed. Further not all potential MoRENet members will be able to make use of its services from the beginning. A certain ICT maturity level will have to be reached before they can connect. The list of potential MoRENet members needs to be updated and an inventory of the maturity status of these institutions needs to be made. In this chapter the concept of federations is introduced as a way for MoREnet to provide services to a variety of client groups. Finally the budget capacity of the potential MoRENet members is introduced: the members are currently paying around $ 1,300,000.- per year for 100 Mbps external bandwidth.

In **MoRENet Services** the services that MoRENet will provide are presented in a layered approach. Within these layers first the “Must have” services will be implemented, followed by the “Should have” services. “Nice to have” services are placed on the back burner and will mostly be implemented by external parties.

In **MoRENet Network Architecture** the layout of the MoRENet infrastructure is presented, including the roadmap to reach this situation. It is the ambition to provide a network with a backbone capacity of 155 Mbps, with minimum access bandwidth of 34 Mbps for those institutions that are able to connect to the MoRENet PoP via fibre optic. An ambitious time line is presented to role out the network, starting in the second half of 2012 and ending and year later in the last quarter of 2013.
In the MoRENet Governance Model MoRENet is to be setup as a separate entity within the state company ENPCT with its own financial responsibility. MoRENet is governed by a Council of Representatives (high level) and a MoRENet Board (day to day management). MoRENet will have a multi-year financial planning horizon and a yearly activity plan to secure a stable financial basis. The service portfolio will be based on Service Level Agreements in contracts with the individual members of MoRENet.

The MoRENet Organisation should consist of a management, with support unit, and three operational units: Network Management, Service Management and User Support. An organisation of 18 fte is foreseen, to be implemented over the period 2012 – 2013.

In MoRENet Tariff Model two tariff models are presented: a bandwidth dependent model and a mixed bandwidth/member dependent model. A policy decision with regard to the model that will be implemented can only be made once the financial model of MoRENet has been finalised.

In the Financial Plan the outline of the organisation as it has evolved in the preceding chapters comes together in the financial plan over the period 2012 – 2016. The first analyses provided financial models that were not sustainable, with the costs of the national backbone being the case breaker. In the Final version of December 2012 no sustainable scenario had been identified. In the spring of 2013 new financial data and some adjustments to the parameters of the plan were fed into the financial plan. As a result a sustainable financial plan can be presented. It is strongly advised to make use of the Movitel offer to provide the circuits for the national network.


As part of the MEGCIP Project (World Bank, 2009) support to MoRENet a number of bids have been prepared and launched to support the expansion and improvement of MoRENet international and national data communication capacity as well as IT infrastructure for data processing and storage. From 2014 two STM1s (155 Mbps each) contracts have been awarded, one to SEACOM and another to UbuntuNet Alliance for improving the MoRENet international access to international and regional research and education network as well as to the Internet.

The number of MoRENet beneficiary institutions has increased and today 20 research and education institutions, including institutions at provincial level are benefitting from MoRENet. The number of research and higher education institutions benefiting from MoRENet will increase to about 89 institutions at the end of 2015 as part of the deployment of national connectivity services provided by Movitel, the telecom operator contracted as part of the MEGCIP Project support to MoRENet in the deployment of the MoRENet national backbone network as well as the access links to the MoRENet beneficiary institutions. Movitel won a bid launched as part of the MEGCIP Project to contract provide national data connectivity services for MoRENet, covering MoRENet national backbone network and beneficiary institutions access links.

One of the weaknesses of the MoRENet initial approach of providing connectivity to the IT computer centres of the universities, limiting the number of students benefiting from MoRENet, has also been addressed within the MEGCIP Project support to MoRENet. An
initiative to establish university wireless campus network has been approved. A bid was launched and 16 wireless campus networks are now being established in 16 higher education institutions interconnect by MoRENet. This initiative is contributing to increase the number of beneficiaries of the international bandwidth contracted to MoRENet. Any one at the university campus network benefitting from this initiative, with the appropriated access credentials can benefit from MoRENet services using his/her own device, including cellphone, IP Pad, Laptop, etc.

A dedicated MoRENet technical team, covering the posts defined in the MoRENet Business Plan (Janz, R., 2013), has been established from 2014, and a MoRENet board has been appointed in 2015 by the Minister of Science and Technology, Higher and Technic Professional Education. These developments are addressing the organizational and structural challenges of MoRENet and they have been proposed in the MoRENet Business Plan.

As part of the Ministry of Science and Technology to MoRENet, through the MEGCIP Project, a number of bids to purchase equipment for the MoRENet NOC (Network Operations Centers) have also been launched and the equipment provided and operational at the Maluana Science and Technology Park.

A number of initiatives to forge partnerships (Weick, K., & Sutcliffe, K., 2005) with other NRENs, has been undertaken by the Ministry of Science and Technology, examples of such initiatives include formal MoU with the RNP (Rede Nacional de Pesquisa), the Brazilian NREN, informal support from TENET and KENET. An example is also the support from UbuntuNet. The MoRENet technical team has benefited from a number of capacity building initiatives such as training and participation in international NREN related events as part of these relationships (cooperation and collaboration).

These are examples of initiatives of support from Government implemented in 2014 and 2015 that are changing the shape of MoRENet and need to further be strengthened.

Figure 4 shows the impact of an approach like MoRENet in reducing the cost of Internet access for research and education community if capacity is purchased in a shared approach [4]. The data above is from the bids launched by MEGCIP in 2011 and 2013 as part of the process of purchasing international and national data communication capacity for MoRENet. While in 2011 the price of 1 Mbps Internet access in a ISP or telecommunications service providers was about 180 USD in average, the same capacity was about 25 USD if purchased in international submarine cable operators and about 12 USD using educational prices.
offered by international submarine cable operators. These prices reduced to 100 USD, 17 USD and 10 USD respectively.

7. Conclusion

Regardless of the difficulties and challenges faced by MoRENet in the first years of its implementation, this paper show that with the appropriate measures and political decisions it was possible to overcome those difficulties and move a strategic project like MoRENet forward.

The prospect of MoRENet are today positive, having experienced fast development in the previous two to three years, that resulted from appropriate allocation of financial resources and building of an environment that allowed the participation of the main interested parties in an initiative like MoRENet.

It is critical at this stage to develop efforts to sustain the momentum gained by MoRENet with the Ministry of Science and Technology, Higher and Technical Education, through the MEGCIP Project, and mobilize additional support from the government, the provide sector as well as from the academia to build on the MoRENet success so far achieved. The increase of the MoRENet international data communication capacity as well as of the national data communications capacity will be critical in the near future, as a result and natural consequence of the increase on the number of beneficiary institutions and the number of users at the campus level.

Looking ahead it will be of great importance for MoRENet to derive strategies to transform this network into a value network for the research and academic community in Mozambique by developing and providing data communication services and not only connectivity and Internet access services. It is to encourage the implementation of MoRENet services included in the MoRENet Business plan, mainly those that are part of the collaboration between MoRENet and RNP, namely: VoIP services for the members of the MoRENet community, the Eduroam services, the federation of identity initiatives, web conference services, hosting services, mail services etc.

The success on MoRENet is also strongly tied to the establishment of the governance structure proposed in the MoRENet Business Plan, and mainly the adoption of governance principles and approaches for this initiative that will allow equal footing of all the interested parties and MoRENet stakeholders in the MoRENet management as well as in MoRENet oversight and decision making processes.

References:


Biography

Robert Janz

After graduating as Theoretical Biologist at the University of Groningen in The Netherlands Robert Janz has, professionally, mainly been active in the area of ICT and Academia. Since 1981 he is employed by the Computing Centre (now named the Centre for Information Technology) of the University of Groningen. Starting as lecturer he became the Technical Director of the Computing Centre in 1995. In 2005 he switched to the position of senior project manager. In this position the focus was on initiating and implementing large multi-partner ICT projects with the University of Groningen as one of the leading partners, such as the ICT part of the LOFAR project, the Groningen Internet Exchange, the Big data project TARGET and the municipal wireless network of the city of Groningen. In the international context Robert has been active in implementing large ICT projects in the Higher Education and Research sector in Africa and Central Asia. In the recent years the focus has been on developing sustainable NRENs in sub-Saharan Africa (Zambia, Mali and Mozambique) and Central Asia, including Afghanistan.

Email: r.f.janz@rug.nl
Implementing Mconf web conferencing at the South African National Research and Education Network

Kasandra ISAAC
SANReN CA, CSIR Meraka Institute, Building 43, Block D, Meiring Naude Road, Pretoria, South Africa
Tel: +27 12 841 2198, Fax: + 27 12 841 4223, Email: kasandra@sanren.ac.za

Abstract
Mconf web conferencing has been launched successfully as a South African National Research and Education Network (SA NREN) production level service from July 2015. This web conferencing service is an Open Source Multi-conference System funded mainly by the Brazilian National Research and Education Network (NREN), Rede Nacional de Ensino e Pesquisa (RNP). Mconf is a research collaboration tool that is web based and that can also be set up as a room based video conferencing system. It can be used for distance education, remote meetings or broadcasting of events and offers a range of collaboration tools such as a whiteboard, document repositories, collaboration spaces, shared notes and more. The service has been integrated with the South African Federated Identities for Research and Education (SAFIRE) to allow users to be able to access the service quickly and easily using their home institutions credentials. By integrating Mconf web conferencing with SAFIRE, the SA NREN hopes that Mconf will encourage institutions that are not registered to SAFIRE to join the federation.

Keywords

Introduction
The need to be able to communicate and collaborate more quickly, easily and effectively with people at different locations has become a necessity in today’s Research, Education and Innovation environments. This may be over a large geographical area or from anywhere with the ease of simply being able to join a meeting by clicking on a link while at your laptop.

This paper will be organized as follows:

Section 1: Structure of the SA NREN
Section 2: Selecting a web conferencing tool for the SA NREN
Section 3: Mconf web conferencing and the Global Academic Network
Section 4: Piloting, Implementing at a production level, Marketing and Operating Mconf web conferencing at the SA NREN
Section 5: Integration of Mconf with SAFIRE
Section 6: Current Usage and Next Steps at SA NREN
Section 7: Open invitation to academic institutions to join the network
Section 8: How to get started

1. Structure of the SA NREN
The South African National Research and Education Network (SA NREN) is comprised of two organisations:

- SANReN CA (South African National Research Network Competency Area at the Meraka Institute of the Council for Scientific and Industrial Research (CSIR))
- TENET (The Tertiary Education and Research Network of South Africa)

With regards to advanced value-added services at the SA NREN, the SANReN CA is responsible for developing and incubating services selected with TENET, while TENET is responsible for operating these services at a production level. The Mconf web conferencing service is currently operating at a production level on TENET and SANReN CA servers and is in the process of being handed over to be operated and supported permanently by TENET’s Service Operations Centre.

2. Selecting a web conferencing tool for the SA NREN

Roesler et al. (2012a) explains in detail that “Video conferencing systems can be organized into four groups: Room, Telepresence, Desktop and Web.” A web conferencing tool, as the name implies, runs within a web browser by simply entering the hypertext link for a meeting room into a browser address bar. This means that the video conferencing software does not need to be downloaded to your machine to participate in a meeting. By having a browser based interface, web conferencing is also able to take advantage of Web Real-Time Communications (WebRTC) technology. The WebRTC website (2011–2014) describes WebRTC as a free, open project that provides browsers and mobile applications with Real-Time Communications (RTC) capabilities via simple Application Programmable Interfaces (APIs). The project initiative is supported by Google, Mozilla and Opera, amongst others. The WebRTC project’s mission is: “To enable rich, high quality, RTC applications to be developed for the browser, mobile platforms, and Internet of Things (IoT) devices, and allow them all to communicate via a common set of protocols” (2011 – 2014: Internet).

According to Roesler et al. (2012a), “the advantage for users of a web conferencing systems is the simplicity of deployment” and “interoperability among different operational systems: users may be running Chrome in Linux, Internet Explorer in Windows, Safari in MacOS, and so on, but everyone still has the same experience.” For these reasons SANReN CA preferred a web conferencing system to other video conferencing options.

The search for a SA NREN web conferencing service began by looking at similar services that were being used by other NREN’s. NRENs with the largest web conferencing deployments were largely American or European based. The criteria for selection of a web conferencing system for the SA NREN were the following: Proven in Use (By trial), Success of other NRENs, Functionality, Maintenance and Support, Ease of Use, Ease to take into production and Cost. Many solutions were explored across the video conferencing groups, such as Adobe connect, Jamvee, Blackboard collaborate, Skype, Google hangouts, Webex, GotoMeeting, Anymeeting, but in the end commercial products were not a viable solution for the SA NREN to implement as cost recovery would be extremely difficult, possibly leading to failure of the value-added service’s uptake and success at institutions.
At the time, the commercial web conferencing product, Adobe Connect was the most popular web conferencing collaboration tool in the NREN space. The SANReN CA had an existing trial version of Adobe Connect running for approximately two years. Therefore, another criteria for choosing a new web conferencing system became “Ease of migration of users from Adobe Connect to the new web conferencing system”.

It was decided to look at similar tools that could be offered to the Research and Education community without having to do cost recovery from users. The options were eventually narrowed down to two open source web conferencing systems: BigBlueButton and Mconf web conferencing.

The most popular open source web conferencing tool known at the time was BigBlueButton. However, the Brazilian NREN, RNP were in a similar position to the SA NREN as they had a large user base of Adobe Connect but were looking for a more cost effective and well supported solution for their region. They therefore provided funding to Projects in Audio and Video (PRAV) in Brazil, to build Mconf web conferencing, an Open Source Multi-conference System, built on and around BigBlueButton.

3. Mconf web conferencing and the Global Academic Network

Mconf is a research collaboration tool that is web based and that can also be set up as a room based video conferencing system. It can be used to create collaboration spaces for distance education, remote meetings or broadcasting of events and offers a range of collaboration tools, such as:

- Real-time communication with audio and video
- Web conferencing rooms
- Document repositories
- Meeting recordings
- Federated Identity Integration
- Load balancing
- Screen sharing, Whiteboard, Notes, Chat, Presentation
- Ease of scalability
- Usage and capacity monitoring
- Possibility of integration with web applications, such as Moodle and more.

The Mconf system consists of various components: Mconf-Web Portal, Mconf-Live Server, Mconf-Recording Server and a Mobile Application. The SA NREN are operating one Mconf-Web Portal which is the front-end for accessing the web conferencing service, three Mconf-Live Servers which form the back-end of the web conferencing service and one Mconf-Recording server. The Mconf-Live and Mconf-Recording servers contribute toward a Global pool of servers which provides high availability and redundancy and will cater for temporary surges in the number of users from institutions or temporary unavailability of a server. As explained by Roesler et al. (2012b), “when the user clicks to open the virtual room, the web portal consults the Load Balancing module and redirects him/her to the most suitable Mconf-Live server, i.e., to the server with the best conditions to serve the conference, that is defined based in several factors, like CPU load, memory and latency”.

Figure 1 shows a simplified version of the Mconf Global Network’s architecture. It shows how the network is organized and the components that are part of it. At the right side of the image is the network’s back-end; this back-end is formed by a group of servers that are the core of the network. The back-end is shared among all institutions that are connected to the network. The elements in the back-end are: (1) the cloud of web conference servers; (2) the monitoring system; and (3) the load balancer.

According to Roesler et al. (2012b), “With this strategy, all NRENs in the world who join the program can unite in an effort to create a global federated web conference service, and this union has the potential to raise a robust, flexible and practical platform, strengthening the communication among the partners”.

The Global Academic Network is monitored and supported by Mconf Tecnologia, a company that is currently providing free support for institutions who want to join the Global Academic Network and commercial support for additional requirements as and if needed. The founders of Mconf Tecnologia were involved in the initial development of Mconf, funded mainly by the Brazilian NREN, RNP and are still actively involved in ongoing developments. Figure 2 shows the location of the Global Mconf web conferencing servers that form part of the Global Academic Network monitored by Mconf Tecnologia.
4. Piloting, Implementing at a production level, Marketing and Operating Mconf web conferencing at the SA NREN

The SANReN CA set up a trial of Mconf web conferencing in 2014, alongside the Adobe Connect trial that was in place for the SA NREN users to test. A few meetings were held with the SA NREN community to test the Mconf system. The system worked well for the most part, but initially there were issues experienced with achieving consistently good audio quality.

During this time, the Mconf team were hard at work with a new version of Mconf-Live (version 0.6.2). After implementing this new version in early 2015, which made use of the WebRTC technology, the audio problems were resolved. Mconf Tecnologia also released a new version of Mconf-Web (version 8.1) which showed a great improvement over the previous version (version 8.0). It was on this version that integration with SAFIRE was tested.

Around March 2015, after testing the service thoroughly, the SANReN CA began handover of the service to TENET who setup the Mconf system in a production environment. TENET did this by increasing the number of Mconf-Live Servers, installing a Mconf-Live Recording server, integrating the new web portal with SAFIRE and creating support structures around the service.

The Mconf web conferencing collaboration service was officially launched as a production level service in July 2015 at two successful Mconf web conferencing launch events. The events took place at the CSIR International Convention Centre (ICC) in Pretoria, on Wednesday 22nd July 2015, and at Cape Peninsula University of Technology (CPUT), Bellville campus on Thursday 23rd July 2015. The events were conducted using the SA NREN’s Mconf web conferencing installation which enabled speakers from the Mconf Tecnologia team in Porto Alegre, Brazil to listen in and present at the sessions, demonstrating
the power of the web conferencing application. *Mconf Tecnologia* is currently assisting the SA NREN to support the service.

The Mconf Mobile Application is still in development therefore this component of the system was not launched as a production service as yet.

5. **Integration of Mconf with SAFIRE**

A feature of Mconf that is very appealing to the SA NREN is that “Mconf-Web is able to obtain user identity from any identity provider that follows the Shibboleth architecture with few configurations, providing access to any user that is registered in this federation” (Roesler *et al.*, 2012a).

Mammen (2013) discussed the creation of a pilot identity federation in South Africa at the UbuntuNet Alliance annual conference in 2013. Two years later, the identity federation of South Africa is now running as a production service. However, the South African Federated Identities for Research and Education (SAFIRE) currently has only four of the 24 universities registered to the SAFIRE federation and only one of the many Research Councils in South Africa registered.

SAFIRE is now operating at a production level but it is a challenge to give Research and Education institutions an incentive to join the federation without having many services available on the federation. Offering Mconf as a federated service hopes to encourage institutions to join SAFIRE by showing them how easy it is to gain access to advanced value-added services, like Mconf, using their home credentials i.e. Username and password.

It is currently not compulsory to register to SAFIRE to access the Mconf web conferencing service but it is planned that it will become compulsory in the future, so that only federated institutions will have access to value-added services offered by the SA NREN.

Mammen (2013) describes a federated solution to identity management as “a trust framework between SPs and IdPs to allow the user credentials from Identity Providers (IdPs) to be used at Service Providers (SPs)”, where IdPs are the Research and Education institutions authentication databases and SPs are the services provided by the SA NREN. Effectively, “when an IdP joins the federation, they will have access to all services within the federation with the ease of mind that the services will not abuse their user's credentials.”

Figure 3 shows a screenshot of the SAFIRE discovery service.
6. **Current Usage and Next Steps at SA NREN**

At the time that this article was written, i.e. on 9\textsuperscript{th} November 2015, there were 137 users registered on the SA NREN instance of Mconf.

Initial uptake of the web conferencing service has been slow with a few key users making use of the service on a regular basis. On follow up with the users who have registered on the service, most users indicated that they are still testing the service but that they have had mostly good experiences using Mconf thus far. Current use cases of Mconf are for Teaching and Learning, National projects and General meetings. For example, meeting spaces have been created under the following project names: Technology Innovation Seed Fund Team, iThemba Laboratory for Accelerator-Based Sciences, Coastal Systems Advanced Mathematical Modelling, H3ABioNet Data Management Taskforce, Directorate of Teaching and Learning, to name a few.

The SA NREN will continue to promote Mconf web conferencing to the South African Research and Education community to increase the use of the service, as many potential users are still to be informed of its availability. They are also assisting the Mconf development team by reporting any problems experienced with Mconf, developing documentation for the system and spreading the message of Mconf to other institutions and NRENs. The SANReN CA is currently exploring possible development opportunities to present to the Mconf team.

7. **Open Invitation to academic institutions to join the network**

The SA NREN has found Mconf to be of excellent technical quality, low cost, easy to setup and with good support available. Mconf web conferencing could help other NRENs, specifically African NRENs, who want to provide advanced value-added services with a low implementation cost to their Research and Education communities.

Roesler \textit{et al.} (2013) makes an open invitation which the SA NREN would like to reiterate:
“Mconf Global Network is open to any academic institution that wishes to participate, and creates a possibility for global resource sharing that is unique in the web conferencing and video conferencing world. The greatest beauty of the system is that it is a real win-win situation for everyone involved, and the network gets stronger when grown. One institution does not have to worry about a temporary failure in the server or a traffic surge, because there are other servers supporting the system as a whole.”

8. How to get started

NRENs or institutions can get started by doing the following (2015a, c, d and f: Internet):

- Test out Mconf at http://mconf.org/
- Read about the Mconf Global Academic Network at http://mconf.org/about/mconf-network/
- Read the documentation on how to join the Mconf Global Network is available at https://github.com/mconf/wiki/wiki/Mconf-Network#how-to-join-the-network
- Read the documentation on how to install the Mconf web portal to access these web conferencing service at https://github.com/mconf/mconf-web/wiki/Deployment
- Learn more about SA NREN instance on the Mconf SA blog at https://mconfsa.wordpress.com/

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Biography

Kasandra Isaac is a Senior Engineer at the South African National Research Network Competency Area (SANReN CA) at the Council for Scientific and Industrial Research (CSIR). She has been involved mainly with the web conferencing value-added service, but has also had exposure to other value-added services such as Federated Identity Management and DNS secondary and also supports other NREN initiatives. Kasandra has a BSc Electronics Engineering degree from the University of KwaZulu Natal (UKZN). She has an Honours Degree in Technology Management from the University of Pretoria (UP) and is currently pursuing her Master in Technology Management.

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How Tech Hubs are helping to drive economic growth in Africa: Background report for World Bank: World Development Report 2016: Digital Dividends

Tim KELLY, Rachel FIRESTONE
The World Bank, 1818 H Street NW, Washington D.C, USA 20433
Tel. +12024589821, Email. tkelly@worldbank.org; rfirestone@worldbank.org

Abstract

Digital technologies have spread rapidly. Digital dividends—the broader development benefits from using these technologies—have not. Digital technologies to benefit everyone everywhere requires improving the “analog” complements to digital investments—by strengthening regulations that ensure competition among businesses, by adapting workers’ skills to the demands of the new economy, and by ensuring that institutions are accountable. Inclusion, efficiency, innovation are the main mechanisms for the Internet to promote development. How can these mechanisms be leveraged to promote Africa’s development? The paper tracks some 117 Tech Hubs across Africa, many of which have been created in the last few years. The paper looks at the patterns of origin by which Tech Hubs are created, why they have a high failure rate, and what makes for success.

Keywords:

Introduction

Digital technologies have spread rapidly. Digital dividends—the broader development benefits from using these technologies—have generally not done so. In many instances digital technologies have boosted growth, expanded opportunities, and improved service delivery. Inclusion, efficiency, innovation are the main mechanisms by which digital technologies promote development (see Figure 1). Yet their aggregate impact has fallen short and is unevenly distributed. To maximize the digital dividends, and mitigate risks, requires a better understanding of how technology interacts with other, non-technical factors that are important for development—which may be considered as the “analog” complements to digital investments. These include strengthening regulations that ensure competition among
businesses, adapting workers’ skills to the demands of the new economy, and ensuring that institutions are accountable.

This paper looks at one very specific interaction between digital investments and analog complements – namely the development of Tech Hubs across Africa. Research carried out for the WDR16 tracks some 117 separate Tech Hubs, many of which have been created in the last few years (see Figure 2). The Tech hubs and co-working spaces cropping up across the Africa continent have consistently made headlines in their effort to bring tech business to the grassroots. Overall, they have brought many new ideas and have provided a rich source of employment and new firm formation\(^39\). However, they also demonstrate a high failure rate and varying degrees of success. This research examines the patterns of origin of the Tech Hubs, the non-digital complements that they provide to the digital technologies, what makes for success, and the impact of government and academic sector support on the role of Tech Hubs in the emerging digital ecosystem in some of Africa’s largest cities.

![Figure 1: How digital technologies impact development](source: World Bank, WDR 16.)

**Looking At the Data**

The Tech Hubs examined over the course of this research can be roughly divided into four main operating types—Academic institution-led, civil society-led, government-led, and hybrid-led. The civil society-led model is by far the most common, constituting 79 out of the 117 currently documented hubs, and it refers to Tech Hubs run by foundations, NGOs, activist/tech developer consortiums, or private sector firms unaffiliated with either government or academic institutions. The Hybrid-led model refers to hubs and incubators, such as Nairobi’s m:Lab East Africa\(^40\), established with World Bank support through infoDev, who self-govern through an administrative board or consortium comprised of

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\(^40\) See: [http://www.mlab.co.ke](http://www.mlab.co.ke).
multiple stakeholders, in this case a private sector firm (eMobilis\textsuperscript{41}), an academic organization (University of Nairobi\textsuperscript{42}), an NGO (World Wide Web Foundation\textsuperscript{43}) and a pre-existing Tech Hub (iHub\textsuperscript{44}). Academic Institution-led and Government-led models refer to hubs that garner the largest chunk of their funding from support from such institutions, and whose organizational structure falls under the supervision of a university or government administrative or oversight body. While these organizations typically avail of university or government real-estate, this is not a definitive criterion as hybrid and civil society led models often do the same, particularly when they have access to subsidized space in government-funded tech parks.

![Figure 2: Tech Hubs across Africa](https://firestonerachel.cartodb.com/viz/a6f8f7a6-7cfe-11e5-9d7e-0ef7f98ade21/m)

Source: WDR16. An interactive version of the map is available at: https://firestonerachel.cartodb.com/viz/a6f8f7a6-7cfe-11e5-9d7e-0ef7f98ade21/m.

\textsuperscript{41} See: http://www.emobilis.ac.ke.
\textsuperscript{42} See: http://www.uonbi.ac.ke.
\textsuperscript{43} See: http://webfoundation.org.
\textsuperscript{44} See: https://www.ihub.co.ke.
Of the 102 hubs initially documented in the World Bank’s 2013 stocktaking of African tech hubs, 27 have closed. Compared to the U.S. Census Bureau’s *Business Dynamics Statistics*’ 5-year failure rates for firms, plotted by industry, the failure rate exhibited by African tech hubs tracked between 2013-2015 is actually ahead of the curve. The tech hubs’ 26% is far more benign than its 60.6% equivalent amongst American communications/utilities firms from 2005-2010.

The high start-up rates for new Hubs, and a deeper dive into the dynamics surrounding surviving tech hubs, provides some insight into determinants of sustainability. In order to examine why some African tech hubs fail while others flourish, and to explore ways to distribute digital dividends equitably rather than entrenching them amongst an elite few, it may be useful to consider the following three issues:

a) The link between the goals of innovation entities and their organizational and governance structure, which often betrays a disconnect.

b) The degree of public sector involvement, which may be an asset for sustainability, but not necessarily for organic growth.

c) The value-added provided by different stakeholders

**Matching Goals and Business Plans and the Hub vs. Incubator Debate**

As part of the research for this paper, interviews were carried out with hub founders and managers, as well as a desk review of organization documentation and survey and case study research conducted by sector stakeholders and observers such as InfoDev, GSMA, IST@frica, and some of the major hubs themselves, such as Nairobi-based iHub and national members of the Fab Labs consortium. The research suggests that tech hub failure often comes out of a disconnect between either the organization’s goals and its business structure or between its goals and the needs of its operating environment. Some organizations pursue a classic Silicon Valley type incubator model, offering seed funding in return for an equity stake alongside a multiple month full-time accelerator program. The investors behind these incubators look for “big ideas,” and with these, aim to secure a significant share of the new tech market. The incubator model focuses on helping the start-ups with product focus, go-to-market, and finding business models, with much of the program working with the startup to establish a good foundation, budgetary plan, and understanding around growth and next stage investors. Other, more open-ended models who self-define as innovation spaces, tech hubs entrepreneurship centers, or eco-system builders prioritize skills over companies. These tech innovation practitioners focus instead on skills training and job creation over seed


46 See: Brownlee, Gary. “Small Business Failure Rates and Causes,” ISBDC, 2014. [http://www.isbdc.org/small-business-failure-rates-causes/](http://www.isbdc.org/small-business-failure-rates-causes/); It should also be noted that calculations using the BDS database covered years during the worst economic downturn in the United States since the Great Depression, a fact which might skew mortality rates for all industries in this context towards the high side.

funding, while others prefer simply to act as an open co-working space providing facilities, promoting collaboration, and creating an entrepreneurial “headquarters.”

The challenge to sustainability comes in when a disconnect arises between innovation practitioners’ goals and the business plans they structure to achieve those goals. In particular, the more open-ended “ecosystem booster” models suffer from a lack of clarity on whether they operate as non-profits or profit-generating enterprises, or whether they aim to make money of their investments or rely on funding from external grants. The now closed Plug and Play Egypt over-extended itself in an attempt to accelerate and mentor start-ups, provide training to young entrepreneurs, and offer financial support to incubatees, without having a sufficient funding pool to support such a wide apparatus. The operating environment in Egypt over the last few years, following the political upheaval of the Arab Spring, has also been quite hostile to new ventures.

Challenges also arise when the aims of even a carefully modeled organization fail to fit the needs of its contextual environment. A debate ensues on whether an incubator or a hub approach is most appropriate for the African tech entrepreneurship scene more generally. Many ecosystem booster models revolve around incubators prioritizing investments in mature companies for quick wins over making skill development opportunities more available to the larger public, and growing the country’s pool of “ideators.” At the same time, tech hubs generally provide no financial guarantee for their mentees, which ultimately may deter potential entrepreneurs from taking their ideas to market. The critique of the latter often looks back to the business model where the incubator’s own sources of funding are closely tied to the success of their investments, which it self-defines as sustainable since the mother organization is particularly invested in its startups’ success. Nevertheless, with such models, the commercialization of skills within the organization and within the start-ups they prop up must be quick, and must be able to go to scale quickly. In contexts where the entrepreneurship ecosystem is still in early development, pickings for such talent sharks and idea-spotters can be slim, and resources might be better used to first boost the skilled labor force and cultivate an idea generation culture.

Models like the partnership between the Nigerian incubator program, 400.NG, and venture capital firm, L5Lab in Lagos, Nigeria, try to fill this gap between talent picking and skill development. In this case, 400.NG liaises with more ecosystem-focused hubs like Focus Hub and Enspire Incubator, to provide accelerator opportunities to high-performing potential entrepreneurs, while L5Lab picks up graduate incubatees to invest in. In Nairobi, the incubation-focused model of m:Lab East Africa, which is physically located in close proximity to the Innovation Hub, one of the best known tech hubs in Kenya went through such organizational growing pains over 2012-13, interviews with iHub staff, May 2014.

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49 Ibid.
50 Interview with Fab Lab Egypt, May 2015; See also for background information: <http://thenextweb.com/me/2011/01/22/from-silicon-valley-to-cairo-plug-and-play-egypt-becomes-a-reality/>
52 Ibid.
physical proximity to the prototype ecosystem-builder, the iHub, with many co-run programs developed between them, aims at a similar symbiosis. The Dakar, Senegal-based Africa-Living Lab, Jokkolabs Dakar\(^{55}\), and Jiguene Tech Hub\(^{56}\), seek to funnel high performers towards incubators such as CTIC Dakar.\(^{57}\) In this way, the various actors along the tech hub innovation driver spectrum can offer a diverse menu of services and mutually gain from the roles and responsibilities of the other.

**Public Sector Involvement—can Elephants dance?**

In his New Trade Theory and critiques on specialized industrial policy, the economist and Nobel Memorial Prize laureate, Paul Krugman, deems it unnecessary for governments to “pick winners” unless an industry is faced with some particular market failure.\(^{58}\) Similarly, discourse on the African tech innovation space debates whether government support for technology innovation—particularly in the form of planned tech parks—spreads or stifles innovation and its social gains. Comparing the ‘Silicon Savanna’ and ‘Silicon Wadi’ ecosystems of Nairobi, Kenya and Amman, Jordan respectively helps exemplify the nuances of these arguments and the merits and demerits of government involvement. Labor, capital, and investment naturally move towards high growth industries in order to maximize their profits and wages. While not necessarily harmful to the chosen industry, government incentivizing firms and labor to do what market forces already encourage can cause resource surplus in certain areas and scarcity in others.\(^{59}\) At the same time, government support can play a powerful role in enabling new entrants to overcome barriers to entry and enter the competitive space, something difficult for small enterprises to achieve in industries associated with high fixed costs and heavy R&D investments.

Nairobi’s tech space prides itself in taking off in-spite, rather than because of the Kenyan government picking winners and hosting entrepreneurship centers. The development of Nairobi’s tech cluster dates to the founding of iHub in March 2010. Growth has spread, first to the rest of the Bishop Magua Centre where it is located (including NailLab\(^{60}\), m:Lab East Africa\(^{61}\) and the longer-established Ushahidi\(^{62}\)), and then and then to nearby Strathmore University (where iBiz\(^{63}\) and iLab\(^{64}\) are located) and along Ngong Road to the GreenHouse and 88 MPH/Startup Garage.\(^{65}\) iHub refers to this as a “community-centred” development.

55 See: [http://dakar.jokkolabs.net/](http://dakar.jokkolabs.net/)


59 Ibid.

60 See: [http://www.nailab.co.ke.](http://www.nailab.co.ke.)

61 See: [http://mlab.co.ke/about/](http://mlab.co.ke/about/)

62 See: [https://www.ushahidi.com.](https://www.ushahidi.com.)

63 See: [http://www.ibizafrica.co.ke/](http://www.ibizafrica.co.ke/)

64 See: [http://www.ilabafrica.ac.ke/](http://www.ilabafrica.ac.ke/)

65 See WDR16, chapter 4.
model (see Figure 3). In contrast, proponents of Amman’s more centrally planned ecosystem argue the Kenyan space grew thanks to the size of the economy overall, and that the lack of centralized guidance would have stunted growth in smaller, more resource poor and politically risky economies, such as Jordan and its conflict ridden neighbors, and Rwanda and its risk of violent spillover from the Congo.

In an attempt to overcome the constraints of a national monopoly of the fixed, mobile, and Internet communications market, and to expand the telecommunications sector and tech business scene, Ethiopia is developing a different type of growth model, based in inward investment. With a top-down policy-level push to link the education and health sectors to government funded tech initiatives, and with a USD$250 million investment in building the Ethio ICT Village (see Figure 4), the numbers of national firms in the sector have grown. The technology park has also drawn increasing numbers of foreign firms to establish a local presence, some of whom, like China’s ZTE and Techno Mobile, have committed to establishing their own incubation centers.

![Figure 3: Community-centred Tech Hub development (à la iHub, Kenya)](source: iHub.co.ke)

Nairobi’s tech start-up scene illustrates the difficulty that governments have in creating technology clusters. A government plan to establish an out of town growth pole (Konza City) as a smart city, has been under discussion since 2008, but has yet to take real shape.

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and has been associated with corruption over politicians acquiring land close to the planned site, with a view to making windfall profits. Instead, the local tech scene has tended to grow organically as firms draw upon, and thus, continually invest in and re-skill the same talent pool. Startups have spun off from established enterprises and even have created new additional enterprises based on common values and mutually reinforcing skillsets. Between the top-down vision and the bottom-up reality, there should be some kind of middle ground that pairs market driven decision-making with public sector guided regulation. While governments can unwittingly undermine a local ICT sector with lax rules on intellectual property protection or burdensome taxes on the import of ICT goods and components, public sector support in the form of positive regulation can be invaluable. The influx of local-content based value-added services in Tanzania’s mobile money market, which has developed since the national payment systems regulations nominally came into effect, demonstrates that regulation is an important source of protection for a business ecosystem. Rather than providing direct funding, governments can use regulatory framework to increase revenue to the ICT sector by removing certain costs of doing business. Such actions include instituting favorable tax regimes or liberal policies on forming legal entities, enabling easier access to finance, or awarding employment permits to skilled workers. Exemplifying this dynamic, London’s first tech cluster, Tech City, grew organically through private sector collaboration while government support through small business friendly tax, business registration, and real estate zoning policies helped brand it as a consistently stable ecosystem.

Figure 4: Public Sector, one stakeholder among many driving London Tech City’s Growth

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71 See: http://www.ft.com/cms/s/0/876bcd12-140a-11e5-9bc5-00144feabdc0.html#axzz41wsbQ3T6
Academic stakeholder value-add—does involvement stimulate or stifle?

In contexts where incubators and angel investors are still nascent and where government and the private sector view one another as antagonists rather than partners, academic institutions can play a unique role as conduit between the two. Typically, research institutes and higher education institutions have links with both the public and private sectors, and while often leaning closer to one side or the other, they do not fall into either camp. In this unique position, academic institutions can facilitate links between innovation practitioners and other networks within the wider ecosystem, including students and academics, as well as providing a unique source of funding to the hub organization or its incubatees. The bridging role these institutions can play will continue to grow in importance as innovation increasingly relies on new developments in the scientific and technological space, which often require costly initial investments in R&D.  

As a case in point, Johannesburg’s Braamfontein area is developing into a self-identified tech hub cluster through a mix of spontaneous, organic private sector generation, and calculated development on the part of academic institutions and government. After the initial success of the some of Braamfontein’s first movers such as CodedinBraam, IMPACT Hub, Black Girls Code, and ThoughtWorks, new practitioners such as TechinBraam, the Branson Centre of Entrepreneurship, Code&Coffee, and the coding and gaming community group “Make Games Johannesburg” have entered the space. A longtime, if increasingly derelict industrial center, Braamfontein’s businesses and suppliers still contribute a lion’s share of Johannesburg’s 40% to the country’s total GDP and have been identified as both a source of demand for locally sourced ICT products and services and an opportunity for externships and mentoring opportunities for potential entrepreneurs. 

The emergence of Braamfontein is a good illustration of the tendency of high tech industry to cluster together. On the supply side, this reflects the way in which new firms spin off from established firms, and both compete for a highly specialized pool of labor. On the demand side, it is driven by “social networking”, or the likelihood that like-minded people will come into contact with each other. This is sometimes referred to a “collisionable moments” (see Figure 5), which are more likely to happen where there is an existing high density of tech graduates. In other words, clusters promote further clustering.

73 See: [http://www.meetup.com/CodedInBraam/](http://www.meetup.com/CodedInBraam/).
74 See: [http://johannesburg.impacthub.net](http://johannesburg.impacthub.net).
77 See: [http://techinbraam.co.za](http://techinbraam.co.za).
Tension over intellectual property regulation and taxation policies have traditionally existed between Johannesburg’s burgeoning tech start-ups and longtime industrial firms and the government. Yet bordered by two of Johannesburg’s most prestigious universities, Braamfontein’s startups and “ideators” were well positioned to avail of academic skill development opportunities and financial support, which often also included parallel financing from the government. In addition, it was arguably the additional financial resources awarded to TechinBraam by the University of Witwatersrand’s Joburg Centre for Software Engineering (JCSE), as well as the university name’s halo effect bringing in a multi-million dollar IBM investment, which also brought the government in as a direct stake-holder in some of TechinBraam programming. JCSE’s acting as a facilitator bringing in an influx of financial and technical support from both government and international private sector firms is arguably what has enabled Braamfontein to sustainably continue its trajectory as the vibrant tech hub cluster we see today.

Figure 5: The likelihood of “collisionable moments” in high-tech clusters


kLab (knowledge Lab), a Kigali-based co-working space for IT entrepreneurs housed within the government sponsored “ICT Park” and run through a hybrid, consortium model

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83 See: http://ventureburn.com/2014/10/government-supporting-sas-startup-ecosystem/
85 See: http://klab.rw.
exemplifies how academic institutions can link facilitators of tech innovation to potential practitioners. The Rwandan government heavily supported kLab’s ecosystem boosting activities as part of its operationalizing the “participatory” phase of its National ICT Plan (NICI-3), which aims to link fibre-optic connectivity to systemic economic growth and equitable distribution of development benefits. When implementing its outreach activities, the tech hub found that since most of the population was still being exposed to the concept of tech entrepreneurship, its link with Kigali Institute of Technology (KIST), National University of Rwanda, and other institutions became one of its main access points to potential clientele.

Yet precisely because academic institutions provide utility to the tech innovation organizations as bridging points between disparate stakeholders and as sources of funding and in-kind resources, their involvement can also inadvertently distort the market and make survival without that support difficult. In a short market survey of other co-working spaces in the region, The Office, a Rwandan ICT-focused co-working space, suggests that when selected spaces are provided with recurrent cost subsidies it becomes much more difficult for other spaces to operate on a purely commercial and sustainable basis.  

Research and Education Networks—more stimulating, less stifling

Enabling tech hub partners to avail of National Research and Education Networks (NRENs) is one way higher education institutions in Africa can provide support for tech innovation, maximizing mutual gains without distorting hub-to-hub competition. Tech innovation practitioners associated with universities can use the NREN networks to strengthen connections to other tech hubs and incubators and support the overall tech entrepreneurship ecosystem rather than propping up the assets of certain particular hubs and incubators over others. In addition to the high speed, reliable, and affordable internet it affords, an NREN’s unique and secure network between member institutions provides both a new communication avenue and a pooled technology platform in a hands-on link between cutting edge scientific research, new technologies, and entrepreneurship ideas and business plan development. Furthermore, its organizational body functions as yet another connector institution aiming to facilitate information and learning exchange between disparate entities.

CB-Tech, an incubator hosted within Cyclotron Réunion Indian Ocean (CYROI GIP), a research and tech focused public interest group created by the University and University Hospital of Réunion, provides young biotech companies access to a high level technical platform and hints at the gains an NREN could provide in the tech innovation space. In addition to availing of to co-working spaces, business plan support, and access to angel investors, CB-Tech incubatees have access to technologies and innovation currently being developed or used within the university or hospital. CB-Tech affiliates also have access to research groups within the university’s partner institutions in France and neighboring Mauritius, as well as national research groups housed within the university such as APLAMEDOM (Aromatic and Medicinal Plants Association of Reunion), and CRVOI, an infectious disease and pharmaceuticals research group. However, CB-Tech still lacks access to the technology platforms and learning exchanges it could avail of should it have access to

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87 Ibid.
89 See: http://www.cyroi.fr/category/pepiniere-entreprise/.
90 See: http://www.cyroi.fr/category/pepiniere-entreprise/.
91 Ibid.
an aggregated network of research institutes, science practitioners, and other affiliated hubs throughout the region.

In contrast, back in Kenya, iLab\textsuperscript{92} and iBiz,\textsuperscript{93} the ICT innovation center and tech business incubator housed within Nairobi’s Strathmore University demonstrate how association with a National Research and Education Network (NREN) can further boost innovation activities. Given that Strathmore University is a member of KENET\textsuperscript{94}, Kenya’s NREN, iLab and iBiz have access to databases, information systems, archives, online computation and collaboration, and interactive learning available to and shared by all other NREN member institutions and affiliated centers and institutes. As a network linking govern-run research institutes as well as universities, the NREN also strengthens iLab and iBiz’s relationship with government entities. Finally, an independently run organization committed to equitably spreading the applied use of communications infrastructure as well as promoting its physical build-out, KENET has extended funding opportunities for targeted research and supported several iLab research projects on e-learning implementation in rural areas and deployment of mobile learning tools.\textsuperscript{95}

KENET’s reach to the Southern and Eastern African regional network, UbuntuNet\textsuperscript{96}, and the global network GEANT\textsuperscript{97}, has opened iLab and iBiz to a larger network beyond traditional university partners. Should other tech hubs and incubators establish similar partnerships with NREN member institutions, the network infrastructure could also function as a network linking the entire innovation ecosystem. On the other hand, should use of a Research and Education Network (REN) become relatively ubiquitous with certain players excluded for some reason, the opportunities would clearly still be exclusionary. However, so long as participation criteria are clear and equitable, opening REN access can support the overall ecosystem and build networks, internship placement opportunities, and collaborative research prospects for the university REN host.

Conclusion

Inclusion, efficiency, innovation are the main instruments spreading development gains from digital technologies, and the African tech hubs and incubator entities, across a wide range, aim to maximize all three in different ways. While digital technologies can make routine, transaction-intensive tasks dramatically cheaper, faster, and more convenient, most tasks also have a non-automatable part, whose execution requires human judgment, intuition, and discretion. In the case of Tech Hubs, the non-automatable part involves issues like choosing the right location, developing an appropriate governance structure, and being lucky enough to have inspirational leadership.

The fact that, of the 117 ICT hubs and incubators documented in this research, only 9 are academic institution-led and another 10 led by governments, suggests that entrepreneurship and innovation are mainly demand and market driven, and do not necessarily revolve around public or academic sector management. Yet analyzing the positive and negative interactions that African Tech Hubs have with government and academic institutions also suggests that a

\textsuperscript{92} See: \url{http://www.ilabafrica.ac.ke/}.

\textsuperscript{93} See: \url{http://www.ibizafrica.co.ke/}.

\textsuperscript{94} See: https://www.kenet.or.ke.

\textsuperscript{95} iLab-iBiz-Strathmore University Interview, October, 2015.

\textsuperscript{96} See: \url{http://www.ubuntunet.net}.

\textsuperscript{97} See: \url{http://www.geant.net/Pages/default.aspx}.
balanced partnership with stakeholders of each sector boosts sustainability for both hub and incubator models. Research into the experience of surviving and newly entering African tech innovation entities over 2013-2015 suggests that both models have important roles to play, so long as their business plans match the needs of their operating environment. Finally, while the majority of African tech hubs do not currently see university partnerships as crucial to growing market-driven tech innovation, this research suggests that innovation entities could be taking more advantage of academic sector resources to embed more deeply in the local ecosystem and better match their operating models to the needs at hand. The academic and non-academic networks provided by academic institutions in general, and Research and Education Networks more specifically, augment tech hub and incubators’ ability to spread digital gains by increasing their access to their client innovators as well as the technology platforms instigating ongoing innovation.

Dr Tim Kelly

Dr Tim Kelly is a Lead ICT Policy Specialist in the World Bank Group, which he joined in 2008, initially with infoDev. He wrote the policy chapter of the 2016 edition of the World Development Report, on the theme “Digital Dividends”. He previously managed World Bank reports on Maximizing Mobile and eTransform Africa, as well as the Broadband Strategies Toolkit. On the operational side, he is currently managing ICT lending programs in Comoros, South Sudan and Somalia. He was formerly Head of the Strategy and Policy Unit of the International Telecommunication Union (ITU), and previously worked with the OECD and Logica. Over the last 25 years, Dr Kelly has specialized in the economics of information and communication technologies. He has written or co-authored more than 30 books on the subject including the World Bank’s "ICTs for post-conflict reconstruction", ITU’s "Internet Reports" and "World Telecommunication Development Report" and OECD’s "Communications Outlook". He has an MA (Hons) degree in geography and a PhD in industrial economics from Cambridge University

Rachel Firestone

Rachel Firestone is working with the World Bank Group on ICT policies and applications, particularly in the contexts of fragility and conflict. Rachel works on ICT projects that use innovation and broadband infrastructure as tools to accelerate economic development process and improve partnership and transparency between governments, academia, the private sector, and grassroots communities.

Prior to coming to the World Bank, Rachel completed her Masters at Georgetown University's Masters of Science in Foreign Service program, in the Global Politics and Security, focusing on community resilience and post-conflict reconstruction. Prior to working in East Africa, Rachel also spent five years in India working on ICTs and multi-stakeholder partnerships to support social inclusion and self-advocacy initiatives with communities recovering from sectarian violence and internal displacement. When she is not working with tech hubs and academic institutions on cross-sector learning and collaboration, Rachel enjoys climbing, running, and cooking very spicy meals.
Abstract

In Zambia over the last four years we have concentrated on creating a National Research and Education Network which can connect our education and research institutions within the country, and the rest of the world. Indeed, affordable and reliable Broadband connectivity has been our cry. Not long ago, Africa was spending in excess of US$70 million per annum for capacity of less than 1Gbp. Zambia in particular, as late as 2012, bandwidth tariffs was averaging US$4,500 per 1 Mbps per month compared to under US$30 in Belgium. Under these circumstances, it was extremely uneconomical for our universities and research institutions to really engage in inter-institutional research collaboration and benefit from opportunities that the Internet had opened up in Europe, the Americas and Far East. Furthermore, the prohibitive Bandwidth costs were a sleep-hold grip to science-driven research that could have been undertaken using the few High Performance Computers on the continent. The NRENs have been a game-changer in driving the cost of connectivity downwards to now average between US$100 to US$200 per 1Mbps per month. However, low cost Bandwidth alone cannot sustain NRENs growth. There is the need for NRENs to offer other value-added ICT services to research and education institutions which cannot be commercially offered by Commercial ISPs. In this paper, the authors address some services that emerging NRENs can implement and offer to their member institutions and highlight some strategic factors that can be considered. The paper also analyses sustainability strategies that high-end NRENs in Europe have implemented in order to remain viable.

Keywords

NREN Services, eduroam, FID, Direct Research Assistance, High Performance Computers, ZAMREN, End-to-end Connectivity, Training and Support, Data, Public and Private Partnerships.

1. Introduction
National Research and Education Networks (NRENs) are emerging all over the world for the facilitation of broadband network connectivity (within the Gigabit region) for Educational
and Research Institutions in order to enable the high capacity demands that are routine in advanced research (exchange of high volume live data for example in collaborative design and medical imaging/telemedicine; transfer of high volume static data; advanced applications like grid computing and high definition video conferencing; etc). Within each continent, continental level Research and Education Networks (RENs) have been set up to implement and operate the regional networks that interconnects the NRENs and also connects them to each other, making researchers so connected as to be part of a global research and education community. These include GÉANT in Europe; CANARIE in Canada; Internet2 and NLR in the USA; CLARA in South America; and UbuntuNet Alliance (UA) in Eastern and Southern Africa. Similar regional RRENs exist in the former USSR; Asia and the Pacific rim.

Zambia Research and Education Network (ZAMREN) was established in 2007 as a registered not for profit organization under the registrar of societies. It began operations in July 2012 being the first NREN in Africa to provide cross-border NREN traffic from Zambia through South Africa. It began with an International Capacity of 155 Mbps connecting the three major universities in Zambia and the network has grown to 1 Gbps connecting to 42 institutions by the end of September 2015. The starting Bandwidth tariff was US$900 per 1Mbps per month. This was considered to be a huge reduction compared to what the commercial provider’s tariff were at that time which ranged from US$4,500 to US$5,000 per 1Mbps per month.

Progressively ZAMREN has been reducing its tariffs on Bandwidth as it procured more capacity through UbuntuNet Alliance and as at 30th September, 2015, ZAMREN tariffs were US$140 per 1Mbps.

Through the process, ZAMREN has been a game-changer in reducing the cost of Bandwidth in the country. Commercial providers have followed the trend set by ZAMREN and respectively reduced their tariff which range between US$200 to US$400 per 1Mbps per month. Inasmuch as the cost of Bandwidth significantly dropped, it is still very high compared to what is obtaining in Europe and is considered by our member institution as being a significant budget line item on operating costs.

![Bandwidth Costs/Tariffs](image-url)
The low cost of Bandwidth has been a major attraction for member institution to get connectivity services from ZAMREN; however as depicted above, the commercial providers have been also lowing their tariffs and the difference between ZAMREN and Commercial tariffs, though significant is no longer a major factor. Strategies will need to be put in place to ensure that this competitive advantage is sustained. One of these is aggregating NREN Internet traffic capacities and procuring this through the Regional Research and Education Network (RREN).

Given that connectivity is the foundation upon which NRENs can provide ICT services, operating physical broadband networks will still be a major part of NREN operations. However, NRENs now more than ever need to provide other services that can take advantage of the physical broadband networks and support and influence research and education development in their respective countries.

This paper briefly outlines what the authors through their own experiences and interactions feel are some of the critical services that emerging NRENs can deploy and embrace to ensure their relevance.

2. Broadband Network based Services

2.1 Cloud Computing
Cloud computing denotes a computing model that enables ubiquitous and on-demand network access to a shared pool of configurable resources, which can be rapidly provisioned and released with minimal management effort (Püschel, Schryen, Hristova & Neumann, 2015). Resources typically refer to IT infrastructures, platforms or software, which are provided as services on a per-usage basis.

There are several cloud computing services that can be offered by the NREN to its member institutions. The most common ones include:

- Software as a Service (SaaS). This is where one or many application deliveries can be offered to member institutions and only the member institution can access the service that is installed on the cloud computer via an internet connection. For example, you can make available learning management system such as moodle to member institutions on the cloud.
- Platform as a Service (PaaS): This is where the NREN provides the development environment if required in this service model.
- Infrastructure as a Service (IaaS): This is where the NREN offers the infrastructure as a service to member institutions. This can be done through virtualization concept.

The advantage to member institutions is that it reduces their maintenance costs because the NREN is responsible for its maintenance and repair, and disaster recovery. Other advantages of this model for the member institutions include as described by Yigit, Gungor & Baktir,( 2014) include:

- Scalability as the NREN is responsible for adding new storage devices as demand increases and upgrading of technology.
• Cost Efficiency: It is cheaper to use the infrastructure because the cost is shared among the member institutions and they do not have invest in upgrading when a new technology is introduced.
• Central Data Storage: High performance computer applications need special computing hardware and software that are expensive and cloud computing provides data centres with lower cost compared to HPC.
• Security: Data security and privacy are taken care of by the NREN and therefore each member institution does not invest in staffing for ICT security.
• Real-time Response: Big data can be processed synchronically by an NREN with its distributed data processing centres which provide a scalable load balancing technology.

2.2 Grid Computing
Universities are under pressure to provide more computing and bandwidth for their staff and students. One of the solution to this challenge is grid computing. A computational Grid is a hardware and software infrastructure that provides consistent pervasive and inexpensive access to high end computational capacity (Frinkle, & Morris, 2015). An ideal grid environment should provide access to all the available resources seamlessly and fairly. Grid computing originated from a new computing infrastructure for scientific research and cooperation and is becoming a mainstream technology for large-scale resource sharing and distributed system integration.

In order to drive innovation and support scientific research there is the need to invest in grid computing as well as a cadre of staff with skills and knowledge in using grid computing. A number of Universities have challenges in teaching HPC because of funding and syllabus (Frinkle, & Morris, 2015). The issue of the syllabus can easily be resolved by institutions like the ACM (ACM, 2015). However, individual Universities cannot afford to procure HPC or grid computing and the NREN can pool resources and provide HPC and grid computing services.

The advantages of Grid computing to NREN members include:

• Possibility of sharing computing resources (e.g., servers, desktop PCs, computer clusters).
• Sharing of storage resources (e.g., hard disk drives)
• Sharing of specific resources (e.g., astronomical telescopes), making them accessible to all participants in the network.
• Efficient use of idle resources as jobs can be farmed out to idle servers especially during off business hours
• Grid computers do not have a single points of failure because if one server within the grid fail there are other resources that are able to pick the load.
• Upgrading of hardware or software can be done without the jobs or customer going offline.
• Jobs can be executed in parallel speeding performance. Grid environments are extremely well suited to run jobs that can be split into smaller chunks and run concurrently on many nodes.
2.3 End-to-end Connectivity
Many large universities have multiple remote campuses. NRENs can provide connectivity between Main Campus and remote campus locations for continuous and cost effective operation of mission-critical applications, such as: VoIP telephony, Student Management System, Email, ERP, Intranet and distributed databases.

2.4 Federated ID
A federated identity is the means of linking a person's electronic identity and credentials, stored across multiple distinct identity management systems for access to electronic infrastructure and services.

2.4.1 Eduroam
EDUcation ROAMing referred to as eduroam is the secure, world-wide Internet roaming access service developed for research and education purposes (Milinović, 2008). Eduroam allows researchers, students and staff from participating institutions to obtain Local Area Network (LAN) and Internet connectivity when they visit other participating institutions. Eduroam, if fully utilized, could be of great benefit to member institutions.

Once eduroam is deployed in many institutions of learning in an NREN, there are many advantages which come with the implementation which can be grouped as technical and accessibility (Chembe C, Kunda D and Simfukwe M, 2014).

Technical Benefit of Eduroam

- In most institutions, internet access at campus is stand-alone, meaning that each institution has implemented its wireless access with different technology and different authentication methods. If a new guest wants to access the network resources, the ICT department has to be informed in advance and that guest needs to be provided with new account or guest account in order to access the network. With eduroam however, there is no need to involve the technical department of the visiting institution for creating a user account. The visitor will use the credentials (username and password) from his/her home university in order to access the network services in the visited institution. This reduces the overhead of the technical staff as they can concentrate on other tasks instead of creating user account for each new user who visits the institution.
- Eduroam is based on a reliable and secure technology for authentication, authorization and accounting, the architecture being build on top of RADIUS protocol. Eduroam allows all authentication mechanisms to be done in a secure manner with reliable encryption mechanisms and not vulnerable to eavesdropping or man-in-middle attack who would want to steal the passwords.
- The use of certification at the device level (or server side) allows only students, academic and non academic staff have access to the eduroam service as only their devices will be installed with the certificates to connect to the service.
- Any device with wireless adapter can connect to eduroam access network without involving the technical team, all one needs is a username and password; thereafter connection is granted on the fly.

Accessibility Benefit of Eduroam

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• With eduroam, there is freedom to access the internet everywhere the service is enabled. Students from one University can go to any other eduroam-enabled institution and access the internet freely during vacation.

• Apart from freedom of accessing the internet, the internet come at no cost for as long as one is a member of participating institution, be it a student or staff. This allows students who come from low income families to access the internet free of charge instead of going to the internet cafes with exorbitant browsing prices.

• Not only freedom of access and free internet access, eduroam service at any institution will allow a user to access the internet as if he/she is part of that institution without any restriction as to what one accesses. With this, all the services (e.g. instant messaging) that users in a particular institution receive will also be received by the eduroam roaming user without blocking any port.

• Eduroam allows users to have access to network-based resources that members of the visited institution access. For example, if research material is only available on a campus network (e.g. accessing the library catalogue), the roaming user will also access this material. Furthermore, depending on the policy of the institution, an eduroam roaming user can as well use network printers and other network based devices for educational purposes.

2.5 E-learning Platforms and Services

There are different expressions used to describe E-learning platforms such as Learning Management Systems (LMS), Course Management System (CMS) or even Virtual Learning Environment (VLE). In these systems, students can access course content in different formats (text, image, sound), as well as interact with teachers and/or colleagues, via message boards, forums, chats, video-conferencing or other types of communication tools (Sanchez & Hueros, 2010)

There are different types of E-learning platforms, ones that are commercial such as blackboard and those that are open source such as Moodle. Most studies have identified Moodle (Modular Object-Oriented Dynamic Learning Environment) as the most used platform in higher education, as well as the most easy to use (Machado & Tao, 2007)

The advantages of the NREN providing open source E-learning platforms and services to its members include:

• No infrastructure costs and free installation: You do not need to invest in the hardware cost of hosting the E-learning platform as a University: the NREN will provide the infrastructure. The member institutions do not have to install the software and this will reduce the implementation time and costs.

• Freely Available: You don’t have to pay annual subscription payment or renewal charges to software companies. The University will only pay a minimal cost of hosting the E-learning platform.

• Flexibility and Customization: Open source products are customizable according to need. New features and tools can be imported from the open source community whenever the need arises.

• Collaborative community. The availability of an E-learning platform at the NREN will provide for a collaborative community and this will minimize the isks of
discontinuing of the E-learning platform and provide for continuous improvement and upgrade of the software

- Increased negotiating power: A large user community can negotiate with providers on a discount on the E-learning platform and services and therefore discounts will be passed on the Universities. Twinomugisha (2007) argues that the cohesiveness of the community expressed through and represented by the NREN tremendously increases the negotiating power of the community. This negotiating power can be used to further reduce bandwidth costs and can even be extended to acquisition and management of many other forms of ICTs.
- Standard documentation: Online help and documentation will be made available to the user community.

2.6 High Performance Computing Resources

High Performance Computing Resources is a cluster of super computers which collectively enable computation and analysis of vast data, for example, in areas such as Water, Energy and Environment, Materials Engineering, Nuclear Physics, Genetics, Neurology, Astrophysics, Bio-informatics, Geosciences, Visualization and Imagining, among the numerous types of research opportunities.

This computing resource provides an opportunity for researchers to undertake science-driven research and to be part of the global research communities in their respective research categories and indeed create innovative solutions for social and economic development.

Purchasing a High Performance Computer by member institution would be very expensive and unaffordable. However NRENs can pool resources from member institutions, donors and Governments to purchase or acquire such resources and make it available to its members at a reduced price. From the researchers’ point of view, this service has a direct impact on their core functions and thus establishes direct relevance of NRENs to member institutions.

ZAMREN has installed two Ranger HPC clusters. Installation was completed in October, 2015. This has generated a lot of enthusiasm among researchers in the Universities and the Ministry of Higher Education in Zambia. Beta testing is ongoing in collaboration with staff at HPC Resource Centre in RSA. Official launch is scheduled for end of November, 2015.

3. Technical Support Services

3.1 Technical Capacity Building/Training

Technical capacity building and training is very important for each member institutions in order to benefit from the increased bandwidth. This will reduce internal network problems in member institutions. Most African educational and research institutions can not afford to hire people with skills such as those possessed by advanced networking specialists, network security specialists and project management specialists (Twinomugisha, 2007). The entire academic and research community can benefit from centralized expertise at the NREN and
the cost to each institution to acquire such expertise is reduced as the costs are shared. Further, the NREN can arrange for training of member institutions technical staff at reduced cost as they can use technical expertise from member institutions.

3.2 Direct Engineering Assistance (DEA)
In most emerging NRENs, member institutions may not have technical capacity for an efficient and effective network. DEA is the ideal way to create hands-on technical capacities directly involving the Network Engineers in the respective institution. NRENs can provide DEA service to promote quality network services in member institutions. This process also enhances close collaboration between NREN Engineers and those at the institution. This also can foster better understanding of technical challenges in the institution and create a common drive for innovation and improvement.

ZAMREN has benefited from this concept through initiatives by Network Start-up Resource Centre (NSRC) and has made DEA a strategic activity.

ZAMREN through the assistance of INASP, will be conducting Direct Engineering Assistance to build technical capacities in member institutions to enhance provision and access of ICT services. It is cardinal for NRENs to assist in this manner and in the process identify new requirement and challenges and be part of providing solutions.

3.3 Direct Research Assistance
The NREN can provide some funds from its budget for research and member institutions can apply for such funds for research purposes. Furthermore, NRENs can source for funds from Government for research and can administer such funds. Governments would be unwilling to provide such funds to private Internet service providers and therefore NRENs can take advantage of such facility and be attractive to member institutions.

4. Human Network Support Services

The human networks are the users and beneficiaries of the physical network. The human networks are the most important part of the NREN and are cardinal for producing and sharing knowledge, and for promoting a continuous research agenda. The physical NREN networks and other ICTs services are enabling tools for the production, distribution, sharing, management and utilization of knowledge.

4.1 Broker and Professional Services
NRENs function as centres of excellence, in service of their clients. The 2014 Terena Compendium Survey identified a number of services being provided by NRENs in the general category of “Brokerage”, that is, NREN using its expertise and knowledge to engage
with the market on behalf of its clients. A prime example of such brokerage is software licensing whereby NRENs can negotiate bulk deals at national level for generic, e-learning and other applications. This seems to be an area in which NRENs can achieve considerable savings for their clients and where there is potential for expansion (compendium.terena.org 2014 Edition)

4.2 Influencing Policies for ICT development and support

4.2.1 Governments:
In most countries, communications infrastructure has been built by governments which has been assigned to parastatal organizations to operate and manage. Examples are that of national telecommunication and power utility companies. NRENs can influence governments to allow them use the extra capacities on this infrastructure to support last-mile connectivity to research and education institutions. Private organizations can also support these initiatives under Public Private Partnerships.

As an example, ZESCO provides inland transit capacities to ZAMREN’s traffic which converges at ZAMREN’s Network Operating Centre. This is a major contributing factor to the low tariffs that ZAMREN charges its member institutions.

ZAMREN has also obtained the Government support for funding last-mile connectivity to member institutions through the Universal Access Fund Initiative.

4.2.2 Communities of Practice
A community of practice is a group of people who share a concern or a passion for something they do, and learn how to do it better as they interact regularly (Wenger 2011). This definition reflects the fundamentally social nature of human learning. It is very broad. It applies to a street gang, whose members learn how to survive in a hostile world, as well as a group of engineers who learn how to design better devices or a group of civil servants who seek to improve service to citizens.

The key elements of communities of practice are:

- The domain: members are brought together by a learning need they share (whether this shared learning need is explicit or not and whether learning is the motivation for their coming together or a by-product of it)
- The community: their collective learning becomes a bond among them over time (experienced in various ways and thus not a source of homogeneity)
- The practice: their interactions produce resources that affect their practice (whether they engage in actual practice together or separately)

There are certain communities that have a direct impact on research and education such as National Library Consortiums, Professional Institutes (Engineering, Agricultural, Medical,
Legal, Financial, e.t.c.), Innovation and Entrepreneurship Centres. NRENs can promote and broaden their services by engaging and collaborating with such institutions to understand their challenges and determine what and how they can benefit from NREN Services.

ZAMREN is working with Zambia Library Consortium (ZALICO) to promote and enhance access and sharing of digital repositories held by the various libraries in the country. ZALICO through its members has embarked on digitizing local content and research outputs. ZAMREN will provide infrastructure for hosting a central repository of these digital resources on behalf of ZALICO to be accessed by member institutions through its network.

5. Conclusion

In order for NRENs to survive and remain afloat they should not just depend on providing bandwidth to their member institutions but invest in value added services. The proposed value-added services in this paper include: cloud computing, grid and high performance computing, eduroam, elearning platform, capacity building, brokering and professional services, engaging community of practice. NRENs should also learn to collaborate and exchange ideas in terms of what value added services have succeeded and thus share experiences and practices.

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Biography

Bonny Khunga is the Chief Executive Officer (CEO) of ZAMREN in Zambia. He holds a Masters degree in Operations Research and Statistics. He has over 30 years experience in Information Communication Technology. Before becoming CEO of ZAMREN, he was Head of Information Technology at the former mining conglomerate, Zambia Consolidated Copper Mines and later as Director of ICT at Copperbelt University, Zambia.

Dr Douglas Kunda is currently the Director for the Centre for ICT Education at Mulungushi University in Kabwe, Zambia. He holds a Doctorate degree in Computer Science from the University of York, UK. He is Fellow of the Computer Society of Zambia and Member of Association for Computing Machinery. He worked as the Project Manager for the Integrated Financial Management Information System (IFMIS) project for the Ministry of Finance. He has presented papers at International Conferences and published in journals.
Abstract

Motivation: National Research and Education Networks NRENs world wide are expanding capacities, forming Academic Telehealth Community Collaboration of health scientists, bridging Science, Technology, Innovation, Education, Assistance and Health Federal Authorities to discuss, finance and work together. The World Health Organization - WHO promotes Universal Health Coverage as a goal for equitable access to health services without pushing people to poverty. Using information and communication technology to bring healthcare to people in remote areas and to those who need health services most is one of the objectives of UHC. Problem statement: RUTE, the Telemedicine University Network from Brazil, under the NREN RNP (www.rnp.br) launched July 2015 its 118th Telemedicine Unit in University and Teaching Hospitals in all 27 states. Over the network collaboration model operates 48 Special Interest Groups in health specialties with 2 to 3 scientific videoconference sessions everyday (rute.rnp.br). RUTE is part of the Brazilian Telehealth Program (www.telessaudebrasil.org.br), coordinated by the Secretariat of Work and Health Education Management (SGTES) of the Ministry of Health, that seeks to improve the quality of the service and basic care of the Unified Health System (SUS). Approach: RUTE’s objectives are: 1. Implement infrastructure for the interconnection of faculty, university hospital and teaching units from different regions of the country, enabling the communication and collaboration between national and international educational and research institutions. 2. Improve care of populations in the most underprivileged regions without specialized medical care through the resulting benefits achieved by the exchange of specialized medical knowledge. The telehealth and telemedicine centers are equipped with cutting-edge equipment, for real-time communication, connected to high performance network infrastructure operated by the RNP. Results: Also newly composing the initiative – RUTE 2.0, started in 2011, today more than half of the federal university hospitals are managed by the Brazilian Enterprise for Hospital Services http://ebserh.mec.gov.br/. In partnership with 18 Latin American Ministries of Health through the Telehealth Regional Project from the Inter-American Development Bank (IADB), RUTE, was certified for best practice of telemedicine by IADB, the Pan American Health Organization (PAHO) and the Economic Commission for Latin America and the Caribbean (Eclac). Conclusions: RNP offers advanced communication infrastructure. Healthcare, R&E has demonstrated more interest
and developed into a Telemedicine University Network RUTE. Important also for its sustainability lies on the participation, coordination, integration and financing from the Ministries of Science, Technology and Innovation, Education, and Health. The model taken into consideration shows how an academic network manages to bring together a number of health institutions to work together to utilize information and communication technology to bring healthcare to people in remote areas and to those who need health services most, remotely manage, collaborate, educate, monitor and evaluate. RNP/RUTE’s unquestionable statement is its ICT and Health proved qualification for remote assistance, education and collaborative research.

**Keywords**

Telemedicine, Telehealth, e-Health, NREN

1. **Introduction**

National Research and Education Networks (NRENs) worldwide are expanding capacities, creating academic telehealth community collaboration teams of health scientists, bridging science, technology, innovation, education, assistance and health federal authorities to discuss, seek funding and work together. The World Health Organization - WHO promotes Universal Health Coverage (UHC) as a goal for equitable access to health services without pushing people to poverty. UHC has been adopted by the United Nations General Assembly as one of the health targets under Goal 3 on health. Using information and communication technology to bring healthcare to people in remote areas and to those who need health services most is one of the objectives of UHC.

RUTE is the Brazilian Telemedicine University Network program, coordinated by the NREN RNP (www.rnp.br). In September 2015 RUTE launched its 118th Telemedicine Unit, all of them located in university and teaching hospitals all over the 27 Brazilian states. Over the network collaboration model operates 55 special interest groups (SIGs) in health specialties with 2 to 3 scientific videoconference sessions every day and 150 participating institutions. The program published last year its second book on its impact in the Brazilian Telehealth initiative as well as in Latin America (rute.rnp.br) (Messina et al, 2014, European Union (2004,2006 and ICY in Health (2013, 2014))1,2,3. As quoted in the foreword: “It is an example of what a country can and has done and what lessons the world can learn from them.” It might provide thoughts and even guidance to policy makers.

2. **The National Research and Education Network RNP**

RNP’s mission is to promote the innovative use of advanced networks in Brazil. Additionally to providing connectivity, RNP makes the interaction between researchers and resources located far away from more developed centers, enabling the deployment of new network applications and protocols, forming integrated scientific communities with great benefits to the public, in areas such as education and health care (www.rnp.br). Under the Social Organization (OS) title, the National Research and Education Network (RNP) is linked by a special contract to the Ministry of Science, Technology and Innovation (MCTI), which coordinates the Program for Maintenance and Development of RNP mentioned above. A pioneer in Internet access in Brazil, RNP develops and operates the Ipê Network, a nationwide high performance optical network. With Points of Presence in all 27 states, the
network connects over 1200 campuses and university units in state capitals and major cities in the country interior. It serves approximately 3.5 million users, taking advantage of an advanced network infrastructure for communication, computing and experimentation, which contributes to the integration of the whole system of Science and Technology, Higher Education, Health and Culture.

3. Telehealth Initiatives Context

RUTE is part of the Brazilian Telehealth Program (telessaudebrasil.org.br), coordinated by the Secretariat of Work and Health Education Management (SGTES) of the Ministry for Health, that seeks to improve the quality of the service and basic care of the Unified Health System (SUS) and to promote tele-assistance and tele-education along with the Open University of the Unified Health System (Unasus) (unasus.gov.br), facilitating access and training to healthcare professionals. The telehealth and telemedicine centers are equipped with cutting-edge IT equipment for real-time communication connected to high performance network infrastructure operated by RNP. Currently, telehealth services, beyond RUTE, are provided in 14 states encompassing 30 thousand professionals from the Family Health Program, present in more than 2 thousand Brazilian municipalities. Since 2012 the Health Ministry officially integrates the Program for Maintenance and Development of RNP, which also includes the Ministry of Education, Ministry of Science, Technology and Innovation, and the Ministry of Culture.

It is worth to note that 9 states, including Amazonas, Ceará, Pernambuco, Minas Gerais, Goias, Rio de Janeiro, São Paulo, Santa Catarina and Rio Grande do Sul, which were the first Brazilian states that in 2007 started the National Telehealth Program, all expanded to provide tele-assistance and tele-education to, least, 100 municipalities each. Two of them, from Santa Catarina and Minas Gerais (Alkmin, M.B.M. et al, 2010) have their projects sustained and turned into services by their Health State Department, assisting respectively 250 and 770 municipalities.

Started in 2011, the Brazilian Enterprise for Hospital Services – EBSERH (ebserh.mec.gov.br/), a new organization responsible for the management of more than half of the federal university hospitals, is also supporting the RUTE.

In partnership with 18 Latin American Ministries of Health (Brazil, Colombia, Ecuador, México, Uruguay, El Salvador, Chile, Peru, Argentina, Guatemala, Costa Rica, Venezuela, Paraguay, Dominican Republic, Haiti, Bolivia, Panamá and Guiana) through the Telehealth Regional Project from IADB, RUTE and the Brazilian Telehealth Program, among others, were certified for best practice of telemedicine by the Inter-American Development Bank (IADB)(Desarrollo…, 2013) the Pan American Health Organization (PAHO) and the Economic Commission for Latin America and the Caribbean (Eclac).

The regional academic network RedClara, and the academic networks, RNP, Renata, Cedia, Cudi, RAU, Reuna, C@ribNET, Internet2, InnovaRED, Conare, Ragie, Raices, RAAP, Reacciun/Cenit, ADSIB, RedCyT, Arandu, Radei, participated in the eHealth Conversations coordinated by PAHO (Conversacione…2014) There is an initiative today lead by RedClara, RNP and Cudi, the Mexican NREN, to stimulate and develop collaborative processes to enable a better understanding of how to promote and run Telemedicine University Networks in Latin America, organizing also collaborative sessions among LA countries on
Telemedicine and health specialties.

4. RUTE’s objectives

The two main goals of the RUTE program can be listed below as:

1. to implement an IT infrastructure for the interconnection of faculty, university hospital and teaching units from different regions of the country, enabling communication and collaboration for national and international educational and research institutions;

2. to improve care of the population in the most underprivileged regions without specialized medical care, through the resulting benefits achieved by the exchange of specialized medical knowledge over the above infrastructure.

The following strategy was devised to create an operational structure for RUTE:

• A national coordination, advisory committee, several special interest groups, centers for the implementation, maintenance, of telehealth communication, and a certified infrastructure for national and local network was responsible to achieve the first objective -- Implement organizational and technological infrastructure;

• Each health institution is invited to submit a project to formally establish its Telehealth Unit, including a physical location and a dedicated team;

• The institutions can propose, create and coordinate Special Interest Groups that promote the development of collaborative activities in health specialties.

5. Collaborative scientific network using Special Interest Groups

Currently, there are 55 SIGs collaborating in areas such as audiology, nursing, cardiology, psychiatry, ophthalmology, child and adolescent health care, pediatric radiology, neurology, dentistry among others. They promote approximately 2 to 3 scientific sessions every day, yielding around 600 video and web conference sessions per year, which are recorded and made available for those who are not able to participate on the live sessions.

Global demands in the field of health care, recent research, new ICT, creation and expansion of each one of the 118 RUTE units in Brazilian universities, university hospitals, research institutes, and certified teaching hospitals guarantee the search for innovation, sustainability and the development of tools, services and processes for education, remote assistance, collaborative research, management, monitoring and telehealth evaluation, using advanced networks.

Since 2013, real-time surgeries and procedures among RUTE Centers are transmitted in Ultra High Definition in the country, and also in some sessions to USA. The 4K technology generates images with resolution four times higher than Full HD. Other research projects such as mobile and 3D applications are being developed.

Starting in September and lasting until the end of December 2015, the SIG on Residency in
Health is promoting weekly videoconference session (VC) updates for preceptors in Residency management, coordinated by the Ministry of Education. This initiative alone is yielding an average of 50 VC rooms and 600 participating preceptors in each session. Participants presence is registered in a web and mobile system specially designed for this purpose (www.rute.rnp.br/presenca).

6. Assessment an important component in the improvement of RUTE

The diffusion and reach of applications of telemedicine depend on its maturity and performance levels. Level of maturity is related to the quantity and quality of research, development of standards and protocols, and acceptance by health professionals. Level of performance depends on the quantity and quality of published results on viability, diagnostic precision, sensitivity and specificity of application, clinical indicators and effectiveness (Bashur, R.L., 2002) However, the literature has emphasized the lack of scientifically recognized evidence of the effectiveness of telemedicine and telehealth. This is a barrier to its consolidation as a consistent alternative for improving service provision, broadening access to healthcare services and reducing costs. Thus, assessing telemedicine projects and programs is essential to allow reproduction of positive experiences and prevention of negative experiences that may still exist. Assessment in health care consists of systematic analysis of safety, pertinence, sufficiency, efficiency, effectiveness, and the positive and negative effects of healthcare programs or activities (Silva, A.B.& Hammerl, L.S.M., (2012) Assessments can indicate whether a program or activity is: pertinent (satisfying the needs, policies and social and healthcare priorities that it aims to apply); sufficient (proportional to needs); efficient (the efforts expended are the most satisfactory possible in terms of the resources employed); and effective (the results obtained are close to the objectives and goals established for reducing the size of a problem or improving an unsatisfactory situation). In the recent context of Brazilian telemedicine and telehealth programs, assessment and academic assessment processes with distinct objectives and methods have been incorporated.

In 2013, Lopes (2013) studied the contribution of RUTE to the development of new healthcare practices, based on the idea that digital health practices are the techniques, practices, attitudes, modes of thinking, and new values that develop as a result of the growth of digital space. The RUTE program provides supportive action that aims to transform the practice of digital health. Lopes set out to investigate the contribution of the project along five axes to describe the condition of the units and establish performance measures for the practice of digital health within the project: The axes were: 1) healthcare education – ENS; 2) remote collaborative care practices – ASS; 3) multicenter research, development, innovation, and research on telemedicine itself – PDI; 4) university hospital management – GES; and 5) social impact – SOC. The method used for this quali-quantitative exploratory study was an electronic questionnaire with 55 semi-structured questions that have been used with coordinators from 72 operational RUTE telemedicine units. The response rate came from 75% of RUTE units; 203 qualitative interviews collected perceptions regarding the network’s impact on the units, which in turn were classified into 14 categories. Quantitative performance was measured comparatively along the five axes for analysis. The study showed that the operational units were mainly focused on using Rute for the education axis, followed by healthcare provision, and then research (Figure 1).
The mean level of importance of axis according to Rute unit coordinators, mean level of local digital health practices before the Rute project and after the operation of the Rute project, and, finally, the gradient indicating the Rute axes with the highest impact on this new healthcare practice.

In view of the assumptions made about the RUTE program, as proposed by RNP, the results obtained in this study of the operational units indicated that the network has instigated and stimulated the development of new digital health practices in university hospitals, especially in education and research.

From April to July 2014, coordinators of the first 100 RUTE units and 55 SIGs were invited to answer an online survey about their current status. Based on these data, it was carried out a process of data visualization in the form of graph to represent the social network analysis on RUTE, focusing on the role of coordinating SIG units. Three main highlights were noted on the graphs, and discussed as relevant results. The RUTE units considered most collaborative are located in the center of the graph and interconnected according to the number of coordination SIGs. They are UNIFESP, UERJ, UFBA, ISCMPA, UFSC, UFES, UFRN and HSL (Brito, T.D.L.V., 2015)
7. Conclusions

RNP’s offering as an advanced communication infrastructure, came as a technological answer to Healthcare and R&E demands that developed into a Telemedicine University Network initiative – RUTE. Great importance of RUTE’s sustainability lies on the participation, coordination, integration and funding coming from the 3 sponsor Ministries: Education, Health, and Science, Technology and Innovation.

The model taken into consideration shows how an academic network manages to bring together several health institutions to work in cooperation, forming a scientific community in a network, which makes use of information and communication technology to bring healthcare to people in remote areas and to those who need health services most. It also remotely manages its activities, promotes collaboration, education, and monitors and evaluates its own performance and results.

Healthcare has been delivered by the Telemedicine network as a multidisciplinary specialty approach. This brings the power of multiple institutions in a networked model to get the best of each one of them, bringing not only its expertise but also resources to make the scientific network a successful social innovation, presenting many lessons to learn.

This and similar examples in worldwide association with NRENs are transforming the way health methodology can be applied, managed, monitored and evaluated. Collaborative approaches and efforts are being undertaken by researchers, health authorities and enterprises to promote also integration of other South American NRENs and the scientific communities at the Brazilian borders. Similar approach is also undertaken with BRICS countries, which also show geographical similarities and challenges.

RNP/RUTE’s unquestionable statement is that ICT and Health proved its qualification as a strong alliance for remote assistance, education and collaborative research.

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Download the book in .pdf format


Biography

P.R.L. Lopes - PhD in health informatics and telehealth. Nowadays, he is Innovation Manager in Telemedicine University Network project collaborating with national project coordination for research, analysis, planning, development, implementation and capacity building in information and communication technology in remote assistance, education, research, management and assessment in healthcare. He also participate in various committees and working groups: Member of Standing Committee member of Telemedicine – Ministry of Health, Rapporteur of the Telemedicine on Communication Commission at the ANATEL (“National Telecommunications Agency”), Specialist on WG2 Interoperability for Devices and Systems in the Special Study Group 78 - Health Informatics at the ABNT (“Brazilian Technical Standards Association”), Specialist on ICT in Health – Survey on the use of ICT Technologies in Brazilian Healthcare Facilities at the CGI.br (“Brazilian Internet Steering Committee”), and Coordinator of Component 1 – Standards on the project for Telehealth Public Goods for Latin America and the Caribbean, sponsor by IADB - Inter-American Development Bank.
MAGIC: A collaboration project to globally connect researchers and academics

Leandro Marcos de O. GUIMARÃES¹, María José LÓPEZ²

¹RNP, Rua Lauro Müller, 116, sala 1103 - Botafogo, Rio de Janeiro - RJ - 22290-906, Brazil
Tel: + 55 21 2102-9660, Fax: + 55 21 2279-3731, Email: leandro.guimaraes@rnp.br

²RedCLARA, Av. El Parque 4680-A, Oficina 108, Santiago, Chile
Tel: + 56 2 584 86 18 , Email: maria-jose.lopez@redclara.net

Abstract

Building on the success of the ELCIRA project, RedCLARA - with partners from Latin America, Europe, the Caribbean, West and Central Africa, Eastern and Southern Africa, North Africa and the Middle East, Central Asia and Asia-Pacific is leading MAGIC (Middleware for collaborative Applications and Global virtual Communities), a cooperation project that aims to significantly improve the ability of researchers and academics around the world to collaborate together. MAGIC might be the first really global collaborative project in the REN environment. But which are the benefits of the project to its partner institutions’ (UbuntuNet and WACREN) members? How can the African researchers and academics benefit from MAGIC? By fostering and easing collaboration and mobility, MAGIC is fostering intra-regional and global collaboration, helping to reduce the technological gap, and as a consequence, in the long term, to reduce the brain drain.

Keywords

Collaboration, identity federations, eduroam, eduGAIN, scientific communities, researchers, academics, RENs, NRENs.

Introduction

A collaboration project to globally connect researchers and academics - aims to establish a set of agreements for all the participating world regions, aimed at consolidating and completing the building blocks of middleware necessary for the establishment of a marketplace of services and real-time applications which will facilitate mobility and the work of global science communities. It started in May 1st, 2015, and will run for 24 months; the project was evaluated and approved for a grant by the European Commission within the Horizon 2020 program.

For its development, MAGIC features the participation of RedCLARA, (coordination institution – Latin America), GÉANT (Europe), RENATA (Colombia), RNP (Brazil), SURFnet (Netherlands), REUNA (Chile), CEDIA (Ecuador), CUDI (Mexico), RENATER (France), GRNET (Greece), CESNET (Czech Republic), CKLN
MAGIC might be the first global collaborative project in the REN environment. However, which are the benefits of the project to its partner institutions (UbuntuNet and WACREN) members? How can the African researchers and academics benefit from MAGIC?

MAGIC is enabling mobility and seamless access to services by promoting the establishment of identity federations connected to eduGAIN, creating awareness of privacy and security issues, and increasing uptake of eduroam. MAGIC is enabling the provision of collaboration tools and services among NRENs based on NREN-run applications made available via a worldwide application market; it is seeking consensus on interoperability of real-time applications and works towards the adoption of standards such as those proposed by the Global CEO Forum. By fostering and easing collaboration and mobility, MAGIC is fostering intra-regional and global collaboration, helping to reduce the technological gap, and as a consequence, in the long term, reduce the brain drain. In addition to the mentioned benefits, of course, looking after enhancing collaboration, MAGIC also provides face-to-face and online training.

Looking after enhancing the participation of African NRENs and their researchers and research communities, through the following paragraphs we will explain the most relevant parts of the project in depth.

Global Mobility

Within MAGIC the second Work Package (WP2) is in charge of working with platforms for mobility, and is led by the Brazilian national research and education network, RNP98 that gained vast experience in this area throughout the work that carried out during the ELCIRA project, coordinating efforts to create AAI (Authorization and Authentication Infrastructure) and eduroam in Latin America.

RNP is coordinating WP2, aiming at the promotion and consolidation of the foundations for creating a framework for authentication and authorization in Africa, the Caribbean, Asia and for Latin America, CUDI (the Mexican NREN) is supporting RNP in the inclusion of new NRENs and their members. This work package is structured to enable other RENs to establish their own regional federation initiatives and will also facilitate the integration with the European initiatives under former TERENA activities such as TF-EMC2 and REFEDS, and will make the necessary arrangements to make it possible to join the eduGAIN interfederation service.

2.1 Identity Federations

NRENs (and their users) have been pioneers in the use of federated authentication to access web-based services that allow users to authenticate once, and then to have access to multiple services. This improves the experience for the user; it reduces the complexity and costs

98 Rede Nacional de Ensino e Pesquisa: [http://www.rnp.br/]
incurred in issuing and managing credentials, while providing accountability and protecting user privacy.

Figure 1: World federation scenario (November 2015) - Reference: REFEDS99

Nowadays, there are 61 federation initiatives, as shown in figure 1, of all initiatives, there are 43 federation in production and 18 in pilot state. This scenario has been changing since 2012, when it was launch the first project focuses on Region REN focused in AAI, eduroam and others initiatives, called project ELCIRA.

99 https://refeds.org/federations/federations-map
The proposal of federation’s work package (ELCIRA’s WP2) was to affect the adoption of the AAI (Authentication and Authorization Infrastructure) standards, aiming standards defined by the eduGAIN Interfederation and integrate them with the Brazilian Federation (CAFe).

The following is measured at the end of the Project:

**Two new federations created and operating in LA**

Regarding the federations, the metric proposed was two new federations. This goal was achieved and surpassed. At the end of ELCIRA project there were three NRENs operating:

- Ecuador (CEDIA - www.cedia.org.ec);
- Argentina (INNOVA RED - www.innova-red.net);
- Colombia (RENATA - www.renata.edu.co)

Although Chile (REUNA - www.reuna.cl) was federated before ELCIRA, the project helped Chile to become member of eduGAIN.
AAI interoperability and interoperation was implemented in a pilot form. Although Authentication and Authorization Infrastructure is a very complex theme, the project has achieved the objectives. Actually, NRENs are integrated to eduGAIN:

- Chile (COFRe)
- Ecuador (MiNGA)
- Colombia (COLFIRE)
- Argentina (MATE) (Joining)

MAGIC's WP2 is working in this area, and its activities are the following ones:

- Analyze the regions that will encompass the project scope to design the best Federation architecture to be implemented per territory and implement that model selected for federation deployment.
- Develop and adapt training material for Identity Federation deployment, supporting local language requirements as necessary.
- Implement online training for Identity Federations in an e-learning platform (NREN or project partner).
- Identity Federation training workshop for Regional RENs.
- Develop and provide in-class training (boot camp) to establish identity management professionals in the region.

### 2.2 eduroam

eduroam (education roaming) is the secure, world-wide roaming access service developed for superior education; it allows students, researchers and staff from participating institutions to obtain Internet connectivity across campus and when visiting other participating institutions by simply opening their laptop.

As same as federation subject, eduroam was worked in ELCIRA project as well. Eduroam’s work package (ELCIRA WP4), has spread the use of the eduroam standard to interoperate a Global Roaming Wi-Fi Service for academic users. The following results can be ensured:

**At least two (2) and ideally four (4) NRENs with have eduroam implemented and inter-operating with the federations for internal use and replication**

As predicted by the group, the countries bellow implemented and federated to eduroam:

- Chile (REUNA - www.reuna.cl)
- Peru (RAAP - www.raap.org.pe)
- Colombia (RENATA - www.renata.edu.co)
- México (CUDI - www.cudi.mx)
- Argentina (Innova|Red - www.innova-red.net)
Seven NRENs should sign an agreement to implement eduroam internally within 2 years from the project end.

It was expected that at the end of the project we have at least those NRENs already committed to implement eduroam:

- Colombia (RENATA - www.renata.edu.co);
- Argentina (Innova|Red- www.innova-red.net);
- Costa Rica (CONARE - www.conare.ac.cr);
- El Salvador (RAICES - www.raices.org.sv); (*)
- Ecuador (CEDIA - www.cedia.org.ec).
- Uruguay (RAU - www.rau.edu.uy); (*)
- Mexico (CUDI - http://www.cudi.edu.mx);

(*) - The implementation is ready but it is still pending sign the MoU and the statement between the nREN and the Global Committee of eduroam. This metric was achieved. It is important to mention that countries of the region signed an agreement for the creation of the Latin American Confederation of eduroam (CLATe).

Figure 18: World eduroam map (November 2015) - Reference: eduroam.org

100 https://monitor.eduroam.org/eduroam_map.php?type=all
MAGIC aims to create eduroam Roaming Operators in at least two countries per region and to provide a local boot camp to develop eduroam experts in at least two countries per region.

MAGIC's WP2 activities in this area are the following ones:

- Develop and adapt training material for eduroam deployment, supporting local language requirements as necessary.
- Implement online training for eduroam in an e-learning platform (NREN or project partner).
- eduroam training workshop for Regional RENs.
- Develop and provide in-class training (boot camp) to establish eduroam professionals in the region.

2.3 Global Mobility results

2.3.1. First workshop on joining eduroam and Identity Federation

The workshop on Joining eduroam and Identity Federation was realized at Arab States Research and Education Network (ASREN) office at Talal Abu-Ghazaleh University (TAGI-UNI) on 8 to 10 September 2015 in conjunction with the 1st International Conference on Open Source Software Computing (OSSCOM 2015).
The ASREN workshop was organized in cooperation with MAGIC Project and EUMEDCONNECT3[^1] Project, and it was designed for staff of the NRENs and Universities and the topics discussed were:

- **eduroam**: the secure, world-wide roaming access service developed for the international research and education community.
- **Federated Access**: effective and secure management of authentication and identity information to build a trust relationship between Identity Providers (IdP) and Service Providers (SP). It devolves the responsibility for authentication to a user’s home institution, and establishes authorization through the secure exchange of information (known as attributes) between the two parties.
- **eduGAIN**: a service developed within the GÉANT Project that interconnects identity federations around the world, simplifying access to content, services and resources for the global research and education community. eduGAIN enables the trustworthy exchange of information related to identity, authentication and authorization (AAI) by coordinating elements of the federations technical infrastructure and providing a policy framework that controls this information exchange.

There were 11 participants from 6 countries: Algeria, Jordan, Lebanon, Morocco, Palestine and Tunisia; Michal Procházka and Jan Oppolzer, both from CESNET (Czech Republic’s NREN), produced the training material used in the workshop, which covered the following topics: Identity Federations, Identity Federation Problems, eduGAIN, eduroam and eduroam policy. Prior to the end of the workshop, and in order to enhance the collaboration

[^1]: [http://www.eumedconnect3.net/Pages/Home.aspx](http://www.eumedconnect3.net/Pages/Home.aspx)
possibilities through the development of these services within the participant countries, the following actions were suggested and are currently under development:

- Morocco:
  - To continue enhancing the eduroam and IdP services;
  - To work on implementing ASREN Community Portal.
- Jordan: to start implementing eduroam in Balqa Applied University which includes 20 campus location in all Jordan;
- Algeria: to start implementing eduroam and continue developing their IdP services. Will also work on NRENNum.net;
- Palestine: to start implementing eduroam in 2 universities;
- Lebanon: started implementing eduroam in AUB and will work on IdP later;
- Egypt: though Egypt people didn’t attend, they will use the training material to start implementing eduroam first;
- Any NREN that completes implementing eduroam and IdP before the end of November 2015 will be recognized and appreciated during e-AGE 2015 Conference in Casablanca 7-8 December 2015.

2.3.2 Second workshop on Joining eduroam and Identity Federation

The Caribbean Knowledge and Learning Network (CKLN) [R3] represents the Caribbean region National Research and Education Networks (NRENs) in the MAGIC project along with a number of other global partners. As such, CKLN coordinated the 3-day training of trainer’s workshop, on eduroam and Federated Identity, from October 7th to 9th 2015. Other elements of the MAGIC project include working with science communities on themes of common interest, and using the middleware being learned and developed in the developing regions.
The Jamaica Research and Education Network, JREN, along with the UWI, hosted this important workshop and saw participation from Jamaican tertiary institutions, as well as representatives from institutions and NRENs in Grenada, Mexico and the Dominican Republic.

The three main goals of the workshop were to contribute to strengthening of NRENs in eduroam service deployment for the Roaming Operator and Campuses (UWI Mona is currently working on deploying eduroam), Federation Policy Development, and SAML federation deployment (for campus, federation and inter-federation). Participants are expected to develop Federation Identity Policies in their countries as well as develop eduroam for their institutions, while training others as part of the MAGIC pilot implementation.

Actual pilot of an eduroam deployment was done during the workshop. This development paved the way for JREN’s proposed deployment of eduroam through the UWI Mona Campus by the first quarter of next year.

The workshop was facilitated Mr. Brook Schofield, Project Development Officer from GÉANT, the pan-European research and education network that interconnects Europe’s NRENs. Most of Mr. Schofield’s recent work is on dissemination of eduroam, which works hand-in-hand with federated identities.

The workshop was held at the Jamaica Tertiary Education Commission conference room located on the Mona Campus of the UWI and is the address used for the Jamaica National
Research and Education Network, JREN. The suggested actions following the training are as follows:

- Jamaica, Dominican Republic and Mexico each to set up a Federation;
- UWI Mona setting up Eduroam (pilot, using UWI servers). Use these for a JREN pilot, as well as regional deployment;
- Participants to encourage and advocate for eduroam to IT Directors at universities;
- CKLN – seek additional PR Material in French and Spanish to support participants in their advocacy;
- Develop technical paper on how to establish an identity provider on your campus, deploying virtual machines – CKLN will undertake this with assistance from Brook and other community members;
- CKLN to work with interested parties in Barbados and the Bahamas;
- JREN will seek to write the Policy document based on the international template;
- Encourage the other NRENs to also prepare a policy document.

Figure 7: Workshop session

Global Services and Real Time Applications for a Global Community

To enable the provision of collaboration tools and services among NRENs based on NREN-run applications made available via a worldwide application market and to seek consensus on interoperability of real-time applications and work towards the adoption of standards such as those proposed by the Global CEO Forum, are two main goals of MAGIC. Again, collaboration it is the key factor, and fostering collaboration, the ultimate aim.

The obvious question is what is MAGIC doing in this arena? Two work packages are focused in the provisioning of these global services: WP3 - Cloud Provisioning and Groupware Standards, and WP4: Agreements for Real Time Collaboration.

3.1 WP3: Cloud Provisioning and Groupware Standards
The Cloud Provisioning and Service-sharing Groupware Standards is the task of WP3 which is led by RedCLARA. Its objectives are:

- To develop a model for inter-operation between NREN cloud application markets of participating world regions based on cloud provisioning and taking advantage of applications developed and run by NRENs across different continents to create a model for a worldwide application market for collaboration tools and services.
- To choose or define the standards in order to make groups’ management systems interoperable across different federated environments, extending federations’ integration to facilitate authorization, user interaction, and global group administration.
- To establish a set of standard requirements for cloud providers to increase security, quality, interoperability and privacy over shared resources and services in the NREN clouds.

The activities that this group is carrying out in order to achieve its objectives are:

- Agreements for a Federated Group Management (FGM) Standard and Application Programming Interfaces (API) for it
- Definition of a set of applications that will adopt the FGM Standard
- Recommendations for service definitions from a marketing point of view
- Pilot portals for the participant regions as appropriate, incorporating the FGM Standard (Colaboratorio: already implemented by RENATA and CKLN)
- Definition of a standard for interoperability of cloud provisioning
- Deployment of a pilot Federated Cloud Service Model for NRENs

Have there been any results so far in this scope? Yes, let’s give a quick look at them:

- Colaboratorio Portal deployed in Ecuador (CEDIA), Costa Rica (CONARE) and Nigeria (NgREN). It will soon also be deployed in the Arab States (ASREN), Argentina (INNOVA RED) and México (CUDI). UbuntuNet and WACREN are also working on deploying it. Colaboratorio’s current tools are:
  - Webconference (MCONF)
  - Social Network for Researchers
  - Large File Sharing (UNINET)
  - Conference Organization (INDICO-CERN)
  - More tools coming
- Open source tools provided locally or in cloud form by NRENs for NRENs

3.2 WP4 - Agreements for Real Time Collaboration

Led by RENATA, the objective of this working group is to seek consensus among participating world regions on the importance of the interoperability of real-time applications
and work towards the adoption of standards such as those proposed by the Global CEO Forum to promote the creation of a worldwide environment for these applications.

Real-time communications are a key work area for NRENs. Almost all research areas, especially biology, medicine and physics, rely on real-time communications in their daily work. In this task, the MAGIC work group aims to expand video-network reach, and functionality by:

a) fostering the adoption of NRENum.net\textsuperscript{102} based dialing,
b) integrating the legacy (SIP capable) global video network with existing web-conference systems to achieve unified communications, and
c) Improving NRENum implementations with secure DNS (DNSSec) adoption.

By expanding use of the NRENum.net service, the group will help to deploy real-time communications as a service integrated with the global community. The NRENum.net based dialing standard will use the Domain Name System (DNS) for universal dialing across the world, and will allow future integration with VoIP networks. The DNSSec implementation will help to provide a more secure ENUM/NRENum.net service, avoiding DNS hijacking based attacks.

In July 8, in Viña del Mar, Chile, within the context of the TICAL Conference, MAGIC held its first face-to-face training session in NRENum.net, with the participation of 11 attendees from Chile, Costa Rica, Ecuador, Mexico and Peru, and the results of the activities carried out by this WP are quite impressive when we consider that during September and October 2015, Ecuador, El Salvador and Mexico were integrated to NRENum.net. MAGIC is expecting for the upcoming month the integration to NRENum.net of Chile, Costa Rica and Uruguay, and for the near future it candidates countries include: Senegal, Nigeria, Morocco and others.

Finally it is important to mention that there is an NRENum deployment course in Spanish, English and French available online and accessible to all the interested people through MAGIC’s website\textsuperscript{103}. In addition there are seven (7) groupware standards in analysis to seek for interoperability.

\textsuperscript{102} The NRENum.net Service is an end-user ENUM service run by the GÉANT Association (formerly TERENA) and participating NRENs (National Research and Education Networking organizations). The service aimed primarily at academia.

What is ENUM? It’s a technology standard used to translate telephone numbers into URL addresses (a domain name). As a result of work of the Internet Engineering Task Force's (IETF's) Telephone Number Mapping working group. ENUM is used to build dialing infrastructure for VoIP, and Videoconference networks at global scale.

\textsuperscript{103} http://magic-project.eu/
Global User Communities

The development and fostering of Global Science Communities is the major duty of MAGIC Project Work Package 5 (WP5) that is led by UbuntuNet Alliance. Its objectives are:

- To invite/select three global research and scientific communities with common topics of research and education interests which include researchers of the MAGIC participating regions to participate in collaborative initiatives using advanced networks and services.
- To extend/update the Funding Opportunities Database and Partner Search application developed by the ELCIRA Project to include information from other MAGIC developing regions and provide valuable funding information for the global communities and other research groups worldwide.
- To foster the collaborative work of Global Science Communities by actively promoting the participation of researchers from all participating regions in European Commission Calls and those of other international funding agencies with high impact in the participating regions and other networking activities.
- To promote and foster the use of collaboration technologies among worldwide research communities, encouraging the proper and active use of the collaborative platforms, services and tools, by supporting them with training material and activities to learn how to use the tools.
- To use these collaborative platforms to spread knowledge and the practices of the Global Science Communities by sharing information and experiences among experts in the priority fields identified, looking to raise awareness of prevailing issues to wider audiences including policy makers, and also, to foster and improve collaboration among researchers of the MAGIC regions.

In order to achieve these objectives WP5 is including the participation of the Research Communities, raising their awareness and training communities on the use of collaborative technological platforms. This is essentially a coordination activity where the project team is working to establish a small set of relevant user communities working on areas/topics that are of high interest in a significant number of world regions. Preference is given to user communities that have experience of working in international projects and have at least worked in projects involving at least two of the regions involved. The global communities are provided with online collaborative tools and are receiving training on how to use them. In addition, the communities are provided with tools to identify funding opportunities for their research. MAGIC is expanding the Funding Opportunities and Partner Search portal developed in the ELCIRA project, and use it to disseminate funding opportunities. Agreements with European and other funding agencies are sought to automatically include information on their calls on the application. Following the experience of projects such as GLOBAL, ALICE2, ELCIRA, GILERA, CHAIN and CHAIN-REDS the project has been organizing Virtual Information days to take advantage of the information provided during EC Information Days and disseminating that information worldwide and specifically to the selected user communities.

Conclusion

The MAGIC collaboration is globally connecting researchers and academics. UbuntuNet-Connect is an outstanding scenario for promoting the project benefits within one of the
project regions and this paper aims at inviting the African research communities to take advantage of the projects’ services, tools and resources in order to enhance their collaboration and research possibilities both in an intra-regional and a global fashion. In time, this will contribute to reducing the technological gap, and as a consequence, in the long term, to reducing the brain drain.

**Biographies**

**María José López Pourailly** is Communications & PR (CPR) Manager of RedCLARA, MAGIC’s WP6 manager (Dissemination and Training). She holds a Licentiate in Social Communication and a Bachelor’s degree in Journalism from the University Andrés Bello (UAB - Chile) in 1998. Before joining RedCLARA as a full time employee (February 2010) she worked as CPR manager at REUNA (Chilean NREN - May 2000 / January 2010), where she also managed CPR for CLARA since November 2004. Previously to her career in the advanced networks area, she worked at several Chilean media (radio, tv, newspapers) and editorials and was full time professor of Multimedia Journalism of the UAB in Santiago. She has wide experience in advanced networks, collaborative and distributed projects development and implementation, web sites design and management, editing and coordination of scientific and of advanced networks, collaborative and distributed projects development and implementation, web sites design and management, editing and coordination of scientific and of advanced networks events; she developed the PR Plan for CLARA, ALICE2, ELCIRA, EELA, EELA2 and worked in the organization of the ALICE – CLARA Launch Event (Río de Janeiro, November 22, 2004).

**Leandro Marcos de Oliveira Guimarães (RNP)** has been Service Manager of RNP since May, 2010. He is responsible for communication and collaboration services, identity management services and strategic hosting services, and currently is member of the GeGC (Global eduroam Governance Committee) and acts as secretary of the Latin American eduroam Committee. He has worked for over fifteen years in Information Technology areas, focusing on projects, planning and operation. He has an MBA in Project Management from IBMEC and another MBA in Information Security from IBPINET - RJ-FUNCEFET. He is certificated as PMP by PMI, COBIT Foundation by ISACA, the EXIN ITIL v3 and the MCSO (Modulo Certified Security Officer) by Modulo. With a Degree in Computer Networks from University Estacio de Sa., Leandro has worked in large companies such as Petrobras, TIM, Claro and Xerox Brazil. He also manages RNP’s activities in the ELCIRA project coordinating actions for AAI between EU and LA, and promoting the deployment of eduroam services.
Useful Flexibilities for African Regional Research and Education Networks

Duncan H MARTIN
31 Stanford Road, Rondebosch, South Africa
Tel: + 27 21 683 8610, Cell: + 27 82 441 5188, Email: dhm@tinmar.co.za

Abstract
The UbuntuNet Alliance is conceived of as an association of NRENs in a given region. The hierarchy Institutions → NRENs → Regional RENs characterises what may be called “the standard REN model”. Regional RENs provide transit to their member NRENs and interconnect with each other over interregional distances. The standard REN model expects no more of any Regional REN.

The standard REN model evolved principally in Europe. In the writer’s view, the circumstances of African countries are too widely disparate for continued as-is adoption of the standard REN model. Greater flexibility is needed to allow UbuntuNet and other Regional RENs of Africa to serve universities that can be reached but are not yet served by an operational NREN.

For example, some countries simply have too few universities to sustain the overhead costs or engender the significant buying power of an NREN. To overcome this, Regional RENs could offer a “catch-all” REN service to individual institutions that are not served by a recognised NREN.

Some African countries are too large, too diverse culturally and/or too patchy in their infrastructural development to enable the ready establishment of a single NREN. Instead, collaborative REN organisations could be established at the sub-national level, and Regional RENs should accept such “District RENs” as legitimate customers.

A Regional REN could also act as a proxy NREN in a country in which the universities use commercial ISPs but no organised NREN has emerged, and so facilitate the founding of a real NREN.

Keywords
Research and Education Networking; UbuntuNet; Connecting Universities; Africa; NREN

The standard REN model

NRENs
The NREN (National Research and Education Network) of a country is conceived of as a non-commercial organisation that provides a variety of Internet-related services to the education and research institutions of the country.
NRENs may differ from each other in major ways such as the scope of their services, the eligibility criteria for participation and their governance and funding models. However all NRENs have in common their nation-wide scope, their non-commercial business model, and their obligation to ensure the direct connection of the institutions that they serve to the worldwide research and education network.

John Dyer’s well-known article [Dyer, J. (2009)] sets out the case for countries to establish and sustain NRENs, while the article [Khunga, B. & Kunda, D. (2015)] draws useful lessons from the successful establishment of ZAMREN, the Zambian NREN.

Regional RENs

In a similar but simpler way Regional RENs such as ASREN, GÉANT, RedCLARA, UbuntuNet and WACREN are conceived of as associations of the NRENs of countries that fall within a specified regional cluster of countries. Regional RENs provide transit services to their member NRENs and they interconnect over interregional distances with each other. Each country has its NREN, or is establishing one, and a Regional REN’s only downstream networks are those of its connected member NRENs.

This is reflected in the simple mission statement of the UbuntuNet Alliance, which reads as follows: To secure affordable high speed international connectivity and efficient ICT access and usage for African NRENs. (See http://www.ubuntunet.net/vision_mission)

The cluster of countries served by a Regional REN often has a political identity. For example, Géant serves the NRENs of Europe, and enjoys sustained support from the European Commission. By contrast, UbuntuNet’s Region, which is referred to as “Eastern and Southern Africa”, does not coincide with SADC or EAC or with any other established political grouping of countries.

REN versus commodity networks

NRENs and Regional RENs have in common their adherence to open interconnection policies, their mutual recognition of each other’s bona fides as RENs, and the concomitant recognition of each other’s ASNs as REN ASNs. The REN community refers to non-REN networks as “commodity networks”.

This distinction should not be seen as separating the good guys from the bad guys! Universities and research institutions need and use access to commodity networks just as much as – some would say more than – they need access to other RENs. For example, many online scholarly journals are hosted on commodity networks. Google search requests go to a commodity network. Important mirror sites such as SourceForge are on commodity networks as are important open source repositories such as GitHub.

However, the distinction is vital for describing current interconnections practice – i.e. what RENs must do, may do, and may not do, by way of interconnecting with other networks.

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104 The DRC, South Sudan and The Sudan, viewed together, form a great swathe that runs for some 4,000 kilometres from the Congo River’s mouth on the Atlantic seaboard, north-east to the Red Sea, and so bifurcates the African continent. The UbuntuNet Region comprises these three countries and all those to the south of this bifurcating swathe, together with the island countries in the western reaches of the Indian Ocean. There are twenty-six countries in the UbuntuNet Region, of which five are island countries off the east coast of the continent. Réunion is not included as it is a French territory.
First, all RENs must provide “REN transit” to their downstream customer networks. This means that they provide IP interconnectivity with other research and education institutions, NRENs and Regional RENs worldwide. Some NRENs, especially in the more highly-developed regions of the World, provide only such a REN transit service.

Second, RENs may provide a commodity transit service to their downstream REN customer networks. This is currently the case for all African RENs, and for the obvious reason that it eliminates the need for the downstream customer networks to carry the costs of separate infrastructures to carry their REN traffic and commodity traffic. In Europe, GÉANT offers a commodity transit service, but imposes an upper limit on the proportion of commodity traffic. Some European NRENs use it. Many European universities procure a commodity Internet service from commercial ISPs and take only the REN transit service from their NREN.

Third, no REN may carry traffic that is neither sourced from nor destined for a REN. RENs implement such rules through judicious control of their BGP route announcements to commodity networks.

The purpose of these rules is to keep the capacity of REN backbones and REN interconnections available for traffic flows between RENs. A former CEO of Internet2 once said in answer to a would-be detractor: Yes! You’re right! Internet2 is indeed almost empty! That’s how it should be – waiting for the next transfer of a massive dataset!

The Standard REN Model

The hierarchy: Institutions → NRENs → Regional RENs, in which NRENs and Regional RENs fulfil the distinct roles described above, characterises what may be called “the Standard REN model”. Of course, it is no more than a business model. It is nowhere enforced by law or authority, but is widely reflected in service agreements between Regional RENs and their member NRENs, and between NRENs and their member Institutions.

There are several well-known instances of deviations from the standard model, especially as regards the exploits of NRENs. For example, in Europe, there are instances of pairs of NRENs establishing a direct, high-speed interconnection between themselves, notwithstanding their mutual interconnection via GÉANT.

Both China and Egypt have two NRENs - one for universities and one for research institutions, possibly because universities and research organisations fall under different government ministries.

In the 1990s and early 2000s the National University of Lesotho and the University of Swaziland were both connected to and served by the South African NREN, UNINET, and its successor, TENET. This deviation from the Standard REN Model started in the days before incumbent telcos had noticed the Internet, and ended when the local incumbents, first in Swaziland and subsequently in Lesotho, took over the provision of Internet services to their national universities.

An interesting deviation concerns NorduNet, the Regional REN that serves the NRENs of the five Nordic countries, which was founded some 15 years before the EC’s Géant Project started off. NorduNet did not become subsumed as part of Géant, and it continues to this day independent of, but collaborating with Géant. Its network has PoPs in each of the Nordic countries, and also in Amsterdam, Frankfurt, London, New York, Miami and San Francisco.
As mentioned above, the UbuntuNet Alliance was conceived as a regional REN according to the Standard REN Model, and so far neither it nor its connected NRENs have deviated from the Standard REN Model.

Quantifying the reach of the NRENs of the UbuntuNet Region

Of the 26 countries in the UbuntuNet Region, 15 have NRENs that are members of the Alliance, and of these, ten are operational and providing services to one or more universities and research institutions. They are: BERNET (Burundi), EthERNet (Ethiopia), iRENALA (Madagascar), KENET (Kenya), MoRENet (Mozambique), RENU (Uganda), SudREN (Sudan), TENET (South Africa), TERNET (Tanzania) and ZAMREN (Zambia).

Saying that 10 out of 26 countries (i.e. 38%) have operational NRENs is a pretty crude way of quantifying the reach of research and education networking in the Region. A better way is to count universities – i.e. to express the number of universities in the 10 countries with operational NRENs as a proportion of the total number of universities in the 26 countries of the Region. The web site of the Association of Africa Universities (AAU) lists the universities in each African country that are members of the AAU. There are some 140 member universities of the AAU in the UbuntuNet Region, and it turns out that almost 100 – i.e. some 70% – of them are located in the 10 countries with operational NRENs.

An obvious improvement to this method, but one that would require data collection from the NRENs, would be to count universities that are actually served by the NRENs.

Why are there not more operational NRENs?

The central role of the NREN

The Standard REN Model is centred on the NREN as the vehicle for the collaborative provision of research and education networking services within nation states. This undoubtedly reflects the environment in Europe where countries have sufficiently many universities and research institutions to justify and sustain NRENs and also have sufficiently de-regulated communications sectors to permit NRENs to form and function effectively.

Notwithstanding the successful operation of UbuntuNet itself and of several NRENs in the Region, it is the writer’s view that the circumstances of African countries are too widely disparate for continued as-is adoption of the Standard REN model. Critical national factors include the number of universities, the extent to which the market power of the incumbent monopoly has been tempered, the lack of funds to seed and evolve an NREN to self-sufficiency, and the willingness of government to devolve control of the NREN to the institutions. These factors, which are denying many African universities worldwide REN connectivity, are discussed in the following sections.

Factors that inhibit the formation of NRENs

Too few universities: Some countries in the Region have only one or perhaps two multi-faculty universities. Examples are Botswana, Lesotho, Malawi, Namibia and Swaziland.

In economic terms an NREN justifies itself, especially in its early years, through aggregating the bandwidth demand of its member institutions and so securing volume discounts that cover
the NREN’s overhead costs and benefit all members. These economics fail when there are too few universities.

**Overly powerful incumbents:** Some countries have regulatory regimes that allow incumbent telcos to continue to dominate the national market, especially as regards transmission capacity and especially as regards governmental and parastatal customers. Incumbents fear the consequences of treating NRENs as special cases that cannot be expected to pay the going rates, and also dislike the desire of NRENs to have their own ASNs and to do their own routing. NREN formation in many countries of the Region was or is being hampered in this way. In particular, this factor is at play in the failure of initiatives over a number of years to establish operational NRENs in Botswana and Namibia.

**Lack of seeding resources:** An NREN is not just a club. It is an operating business (albeit a non-profit one) with, inter alia: bank accounts, customers, suppliers, services, service contracts, creditors, debtors, prices to be set, auditors, taxes to be paid, a Board of Directors, a constitution, governance processes, communications licenses, policies, employees, a CEO, routers, servers, rented network capacities, etc. Conceiving and launching a new NREN is a significant project that requires significant seeding resources: (a) a project team that brings together contacts in the universities, good understanding of what has to be done, and business experience; (b) a respected retired Vice-Chancellor or other senior university personage to act as the public face of the project (Project Sponsor); (c) an identified person who is going to become the first CEO and is available full-time; and (d) working capital from which to bear the travel, workshop, secondment, salary, accommodation, legal and other expenses of the project until such time as the NREN is operational and generating sufficient revenues.

In the writer’s view it is primarily the lack of seeding resources that has denied Zimbabwe an NREN. Zimbabwe has many universities, a well-developed telecommunications infrastructure and a de-regulated telecommunications regime with at least three competing operators each of which serves a number of universities. Prices are quite low, which weakens the viability of a start-up NREN and makes seed funding essential. Notwithstanding several meetings of Vice-Chancellors and representation at several UbuntuNet meetings, an adequately conceived NREN has not materialised.

**Failure to evolve from project to sustainable NREN:** In many countries the establishment of an NREN was (or may be) first started by a government department or parastatal authority. Start-up funding by the World Bank or international donors is often available to such public initiatives. Examples include:

- South Africa (UNINET Project of the Foundation for Research Development, a parastatal institution, 1987)
- Kenya (Department of Education, funding from the USAID Leland Initiative, 1999)
- Mozambique (Department of Science and Technology, World Bank funding, 2006)
- Rwanda (Department of Education, 2006)
- Burundi (Executive Secretariat for Technology, Information and Communications, World Bank funding, 2013).

The provision of Internet access to the universities was the primary objective of such projects and their funders. This was well understood, and governments can readily call upon the services of incumbent operators to provide such services.

What is not always understood is the importance of establishing a *membership-based* NREN as the vehicle that will sustain and develop such Internet service provision into the future.
The role of the initiating department or authority is not just to initiate research and education networking in the country, but also to ensure the establishment of an organisation that has the support of the universities and research institutions and that can assume responsibility for sustaining and developing research and education networking across the country and into the future.

Membership-based NRENs were established in Kenya, South Africa, Sudan and Tanzania; and is this now happening in Burundi, and Mozambique.

A more flexible De-Facto Model for Regional RENs

This paper advocates that the UbuntuNet Alliance should be willing to deliberately deviate from the Standard REN Model in certain specific ways to ameliorate the hindrances to NREN-formation described above, and indeed, where applicable, to overcome the absence of an NREN. A more flexible de-facto REN model is needed that allows UbuntuNet and perhaps also other Regional RENs of Africa to serve universities that can be reached but are not yet served by an operational NREN. Some ideas in this regards are presented below.

What about a “catch-all” service?

As mentioned above, there are still many countries in the UbuntuNet Region in which there is little prospect of an NREN being established in the foreseeable future. In total there are some 40 universities in the Region that are members of the Association of African Universities but have little prospect of being served any time soon by an operational NREN.

However, for such universities, there could be a simple win-win outcome, with no injured parties, if the Alliance were to offer “catch-all” membership and REN services to them. Such institutions would become members of the Alliance, perhaps in a special “catch-all” category, and would connect to UbuntuNet and use UbuntuNet’s services. Sensible modifications to UbuntuNet’s policies would be needed to ensure that the eventual establishment of new NRENs would not be prejudiced.

Where a country has one dominant “national” university and a number of smaller higher education and/or research institutions, the Alliance could accept the dominant institution as a catch-all member provided that the smaller institutions are permitted to share the same connection to the UbuntuNet network. Such an arrangement would stimulate the formulation of a business framework for collaborative networking that could evolve into an NREN.

Interestingly, such a “catch-all” REN service would be akin to the catch-all sign-on services offered to individual scientists by some identity federations. It would constitute quite a significant elaboration of the Alliance’s role and would need to be guided by well-informed policies and case-by-case investigations and preparations. In any country the Alliance should always, as a first priority and option, seek to support the emergence of an NREN. It should only offer services itself to the institutions of a country only with the support of the institutional leaders concerned, and preferably concurrently with renewed efforts to establish an NREN.
What about District RENs?

Some African countries are too large, too diverse as regards language and culture and/or too patchy in their infrastructural development to enable the ready establishment of a single NREN. In such circumstances, NREN-like organisations could be established at the sub-national level, and Regional RENs could accept such “District RENs” as legitimate customers.

Such an approach could possibly speed up the process of reaching the many universities in the DRC, where the current efforts to establish Eb@le, in both organisational and networking terms, are concentrated in and around Kinshasa.

Again, sensible modifications and additions to policies would be needed; for example, to facilitate the merger of such District RENs into a single NREN once circumstances so permitted.

What about the Regional REN as a proxy NREN?

The Alliance is in a position to establish REN connectivity in countries such as Zimbabwe that have relatively well-developed infrastructure and in which the universities use the services of commercial ISPs, but in which no organised NREN has emerged.

Working closely with some path-finder universities, the Alliance could secure an allocation of IP addresses from AfriNIC, with which the universities would renumber the external interfaces on their networks. The Alliance would also secure an ASN from AfriNIC, and acquire a BGP-capable router – the proxy-NREN router – to deploy at a suitable Internet Exchange. Finally the Alliance would connect this router to the UbuntuNet regional network. The universities would instruct their ISPs to provide Layer2 connections to the proxy-NREN router.

In this way a network could be established that operates like an NREN. It could be managed and operated by a local team directed (initially) by the Alliance. This proxy-NREN network, as an operational reality, would be the kernel around which the universities would come together, with facilitative assistance from the Alliance, to establish a new, membership-based NREN organisation. In due course the new NREN would take over responsibility for the network.

How can an unreached NREN or institution connect to UbuntuNet?

There are three ways in which a BGP interconnection between an unreached NREN or catch-all institution and UbuntuNet could be set up, and so enable the NREN or institution to use some or all of UbuntuNet’s Internet services.

Self-provided transmission circuit to an UbuntuNet PoP

An unreached NREN or catch-all member institution could, at its own expense, rent or secure the use of a dedicated L2 cross-border circuit from its own border router to an interface on any convenient UbuntuNet device in some reached country. UbuntuNet could supply onward transmission capacity from such a device to one of UbuntuNet’s border routers, and a BGP interconnection between the NREN and UbuntuNet could be set up.
An NREN is unlikely to incur the cost of such a dedicated cross-border L2 circuit in addition to incurring the charges from a local commercial provider of IP transit services. Consequently the NREN’s purpose in procuring the use of such a dedicated border-crossing L2 circuit would almost certainly be to use UbuntuNet as the NREN’s sole provider of commodity connectivity in addition to REN connectivity.105

**GRE tunnel to an UbuntuNet transit node**

GRE tunnelling is a way of setting up a direct BGP relationship between two ASNs for which there is no transmission circuit that directly links their respective border routers. Consequently all traffic between the two networks must traverse other ASNs. The BGP packets are encapsulated so that the intervening border routers make no route announcements but merely route the packets.

An unreached NREN whose network receives a global IP transit service from a commodity ISP but is configured as a distinct ASN could interconnect with the UbuntuNet network via a GRE tunnel. Note that the NREN’s network may be configured entirely within the network of a local operator and be operated by that operator. The requirement is that at Layer 3 – i.e. as an internetwork – the NREN’s network is set up as a distinct network with its own ASN.106

Note that if an NREN were to use a border-crossing GRE tunnel to interconnect with UbuntuNet, then all traffic flowing into or out of the NREN from or to UbuntuNet would be part of the NREN’s international IP transit traffic. Consequently the NREN would be paying its IP transit provider (ISP) for such international traffic in addition to paying the applicable UbuntuNet charges. For this reason the Alliance should not expect such an NREN to purchase commodity IP transit from the Alliance. The NREN’s purpose in connecting via the GRE tunnel would probably be limited to secure what no commodity provider can provide - access to the REN network regionally and globally.

For two ASNs to set up a GRE tunnel between them both must have upstream transit providers so that there are some IP routes between them via intervening networks. At the present time UbuntuNet purchases IP transit only in Amsterdam and London, and consequently could not terminate a GRE tunnel from any NREN on the Regional REN Backbone.

Of course at UbuntuNet’s end of any such interconnection, the GRE tunnel is necessarily configured within the network of a commodity ISP from which UbuntuNet buys IP transit services. For such a termination to be available, UbuntuNet must buy commodity IP transit from suitable commodity operators at suitable locations in the Region.

**The Alliance could provide an L2 connection**

The Alliance could, in principle, procure a cross-border link between its nearest node and a suitable node in the unreached country concerned, and could treat the costs thereof as part of

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105 ZAMREN connected to UbuntuNet in this way for many months. ZAMREN rented an L2 circuit from Liquid Telecom between Lusaka and a TENET switch in Johannesburg, and TENET provided transmission capacity to extend the L2 circuit from the Johannesburg switch to the UbuntuNet border router in Mtunzini.

106 For many years, during the pre-UbuntuNet era, TENET interconnected with both Géant and Internet2 via GRE tunnels. Telkom SA operated the entire TENET network, including the routers, but the network was configured as a distinct autonomous system with its own ASN (AS 2018). Both GRE tunnels had a TENET border router in Cape Town at their southern ends, while at the northern ends one terminated on a Géant router in London and the other on an Internet2 router in New York City. Both tunnelled through the networks of Telkom SA and its Tier1 transit providers.
its overall cost structure. A pre-requisite for such a step could be the connecting institution’s committing to an enduring minimum bandwidth order.

This suggestion entails an enlargement of the Alliance’s approach to reaching countries, in which the primary determinant is that an NREN or university is willing to commit to an enduring order quantity, rather than an approach that is primarily driven through AfricaConnect’s planning processes. It is worth noting that the latter approach lacks any requirement for commitments to minimum bandwidths order, as the prolonged failure of RwEdNet to connect to the UbuntuNet router in Kigali demonstrates.

In the writer’s opinion, the Alliance should not be intimidated into inaction by assertions that today’s traffic volumes to and from a particular institution or country are too meagre to justify a REN connection. UA’s role as a stimulator and enabler is very important, and decisions to establish links should be based upon assessments of the potential for meaningful traffic volumes to develop.

Fair pricing

The Alliance’s present services and prices do not differentiate between service handoff to an NREN at a node within the NREN’s country ("reached countries") and service handoff at a node that is one or more border-crossings removed from the NREN’s country ("unreached countries"). For an individual university in an unreached country to use UbuntuNet services, it would have to bear the cost of a cross-border link to an UbuntuNet node, in addition to which it would be charged at the same service prices as are charged to NRENs in reached countries.

In so far as the EC’s major contributions to the AfricaConnect developments have benefitted some countries and not others, in the post-AfricaConnect era the Alliance would be justified in devising price schemes that made UbuntuNet connections more affordable for institutions and emergent NRENs in as-yet unreached countries.

Conclusion

For some time the writer has believed that the Alliance should be willing and able to push the boundaries of the standard regional REN model by providing services directly to universities in countries where, for whatever reason, there is no effective service-providing NREN and little prospect of one emerging. This paper advocates that the UbuntuNet Alliance should deliberately deviate from the Standard REN Model in certain specific ways when and where the connectivity and service needs of more education and research institutions of the Region would be better served by so doing.

This would constitute quite a significant elaboration of the Alliance’s role and would need to be guided by a well-informed policies and case-by-case investigations and preparations. For any country of the Region, the Alliance should always, as a first priority and option, seek to support the emergence of an NREN. It should offer services itself to the institutions of a country only with the support of the institutional leaders concerned, and preferably concurrently with renewed efforts to establish an NREN.

A first step would be to determine and understand what regulatory, networking and business issues would have to be addressed for universities in selected countries to be able to connect their networks to UbuntuNet and receive the Alliance’s REN transit services. Strategies for and policies governing direct service provision would also need to be formulated.
References


Biography

Duncan Martin was an applied mathematics lecturer and researcher and, from his mid-forties, a general manager of research and ICT services. In 2001 he was appointed as the first CEO of the South African NREN, TENET, of which he was a founding director. Together with colleagues from Kenya, Malawi, Mozambique and Rwanda, he co-founded the UbuntuNet Alliance in 2006, and served on its Board until his retirement from TENET in January 2013. He now consults to the Alliance and NRENs, and is a non-executive director of local companies including E-Schools Network, Internet Service Providers’ Association and ZA Central Registry.
Building a Cyber Security Emergency Response Team (CERT) for the NREN Community – The case of KENET CERT

Peter MUIA¹, Meoli KASHORDA¹, Kennedy ASEDA¹, Ronald OSURE¹, Martin NJAU¹

¹Kenya Education Network, P.O. Box 30244 - 00100, Nairobi, Kenya
Tel: + 254 732150500, Email: info@kenet.or.ke

Abstract
Kenya through the regulator, Communications Authority (CA) has setup a national Cyber Security Emergency Response Team (KE-CIRT). This national CERT in Kenya has several sector CERTs with the Kenya Education Network (KENET) having the mandate of setting up and running the education sector CERT in Kenya (Communications Authority of Kenya, 2015).

The purpose of the KENET CERT is to identify threats in the Internet and communicate the same to its community (Kenya Education Network CERT, 2015). It also identifies threats within the community and communicates the same to the rest of the Internet community. Additionally, it provides a mechanism where security incidents can be reported and resolved within the KENET community. Experiences are shared with the community and documented for future reference. The CERT is also responsible for making sure that KENET systems and network are safe from security threats. KENET setup the KENET CERT that is run and operated at KENET by the KENET team. This paper and conference session describes the setup of the KENET CERT, the model of operation and the impact and experiences learned from running an NREN CERT in Kenya.

Keywords
Kenya Education Network, Cyber Security Emergency Response Team, Security, National Research and Education Network

1. Introduction
KENET is the National Research and Education Network (NREN) of Kenya and it is licensed by CA as a not-for-profit operator serving the education and research institutions in Kenya. KENET operates the CERT for the academic community (Kenya Education Network, 2015). The KENET CERT was established in 2014 with a mission to respond to security emergencies on the Internet, serve as a focal point for reporting and facilitating the corrections to security vulnerabilities, analyze security related data to develop and disseminate countermeasures and prevention techniques and raise awareness and understanding of security trends and issues within the KENET community.

A CERT is an organization or a department within an organization formed to study Internet security, discover vulnerabilities and to provide security related assistance to the identified community. The KENET CERT offers emergency response service and shares information for improving web and network security. It strives for a safer, stronger Internet for the education and research community in Kenya by responding to major incidents, analyzing threats, and
2. Motivation for Setting up a CERT at KENET

The number of computer security incidents in the KENET community and the country at large had grown at an alarming rate. Traditional computer security efforts focused on the physical security of systems and the confidentiality of data. As such the risk of denying user's network services or causing a loss of data was rarely addressed, except on a reactive basis when the damage would have already been suffered. With the increase in the use of online applications by universities and research institutions in Kenya, the user base for network computing resources has expanded to such an extent that network availability and data integrity were just as important, and therefore a new approach was needed.

KENET has been providing broadband connectivity to its members and this has been increasing over time. Currently, KENET is distributing 9 Gb/s bandwidth to its members. This is by distributing 4.5 Gb/s International traffic, 4 Gb/s Google Cache and 0.5 Gb/s Akamai traffic. KENET has also grown its shared services and has been providing services such as web hosting, backup services, data recovery sites, DNS services, cloud services and virtual servers. This led to an increase in security threat to not only the KENET infrastructure but also to the services hosted at KENET and the institutions served by KENET. A coordinated method for responding to computer security incidences at KENET was therefore adopted.

3. KENET CERT Services

The Goal of the CERT was to create a team at KENET that would ensure the confidentiality, Integrity and availability of both the network and the systems at KENET. The CERT therefore provides the following services in order to achieve this goal:-

- Facilitate the centralized reporting of incidents – Whenever there is a security incidence affecting the KENET network, the KENET CERT facilitates a quick communication channel through the mailing list, web portal or even Short Message System (SMS).
- Perform training and raise the security awareness of users – The KENET CERT team conducts both the Cyber security training for systems administrators and security awareness training for non-Information Technology (IT) users.
- Resolving security-related tickets as part of the KENET help desk. These issues range from web applications hacks that include defacements, SQL injections, Denial of Service, Cross-site scripting, email spamming, loss of backups among other security-related complaints from the community.
- Promote computer security policies within the KENET community by creating policies such as the web hosting policy and business continuity plan. Additionally, the KENET CERT team is usually represented at the KE CSIRT and any security forums within the country and outside the country whenever it is possible.
- Alerts and Announcements – Periodically, the KENET CERT performs vulnerability analysis of the systems hosted at KENET and also analyses the various logs of both the network devices and the systems logs and intrusion detectors. Any relevant findings are forwarded to the members of the KENET CERT mailing list or to specific
Institutions if the information is considered to be confidential.

- **Collaboration** – The KENET CERT team collaborates with other CERTs by receiving alerts and vulnerabilities that are noted on the Internet. Similarly, when KENET discovers any vulnerability, the same is communicated to other CERTs. KENET also publishes these vulnerabilities on the KENET CERT portal which is publicly available.

- **Incident Tracing** – In case of a successful security breach, the KENET CERT is involved in doing forensics to determine what actually happened and to advice KENET on how to prevent such incidents in the future. In case an incidence was service affecting, a Reason for Outage (RFO) is prepared and sent to the institution’s ICT management.

- **Securing the KENET infrastructure** by ensuring that network devices and systems are hardened before they go live.

4. **Methodology used for setting up the KENET CERT**

A phased approach was adopted that included 5 stages as described below. Although these stages are described in isolation, they overlap and the process was seamless and continuous.

4.1 **Stage 1 Requirement Analysis and Specifications**

This stage entailed understanding KENET as an NREN and the community it serves and the types of computer threats and risks faced. It also involved understanding how universities and research institutions handle security within their organizations. Any security threat that could lead to compromise of data, unauthorized access, and network misuse, denial of services and loss of credibility was identified at this stage. Anything to do with security and security incident handling within KENET was identified at this stage.

4.2 **Stage 2 Planning**

At this stage, the services to be provided by the CERT to mitigate the threats identified in the first stage were defined. The KENET CERT services that were identified can be grouped into three broad categories:

- **Reactive services**
  
  These services are triggered by an attack or security ticket request, such as a report of a compromised host, wide-spreading malicious code, software vulnerability, or something that was identified by an intrusion detection or logging system.

- **Proactive services**
  
  These services provide mechanisms to prepare, protect, and secure the KENET community systems in anticipation of attacks, problems, or events. This is necessary because it reduces the number of incidents in the future.

- **Security quality management services**
  
  These are services that support computer security within the KENET community such as the IT audit, penetration testing policies or security training of staff.

Research on the operations of other CERTS was carried and benchmarks chosen. The CERTs chosen for benchmarking include:-

4.2.1 **DFN-CERT**

DFN-CERT offers consulting and services for improved Internet security. This is
by providing the protection of computers and computer networks from attacks and the security of electronic communications. The CERT focuses on security expertise in close cooperation with German and international computer emergency response teams (DFN-CERT, 2015).

4.2.2 Terena TF-CSIRT

TF-CSIRT is a task force that promotes collaboration and coordination between CSIRTs in Europe and neighbouring regions, whilst liaising with relevant organisations at the global level and in other regions. It also develops and provides services for CSIRTs, promotes the use of common standards and procedures for handling security incidents, and coordinates joint initiatives. This includes the training of CSIRT staff, and assisting in the establishment and development of new CSIRTs. The task force further liaises with FIRST, ENISA, other regional CSIRT organizations, as well as defence and law enforcement agencies (TERENA, 2015).

4.2.3 US-CERT

US-CERT is responsible for analyzing and reducing cyber threats, vulnerabilities, disseminating cyber threat warning information, and coordinating incident response activities. It brings advanced network and digital media analysis expertise to bear on malicious activity targeting the networks within the United States and abroad (US_CERT-2015).

4.2.4 FIRST

FIRST brings together a variety of computer security incident response teams from government, commercial, and educational organizations. It aims to foster cooperation and coordination in incident prevention, to stimulate rapid reaction to incidents, and to promote information sharing among members and the community at large (FIRST, 2015).

4.3 Stage 3 Implementation

The implementation phase involved the assembly of a team within KENET with both personal and technical skills of running a CERT. Some of the personal skills considered included communication skills, team work, diplomacy, integrity and problem solving skills while the technical skills considered included knowledge of security principles and incident handling skills.

The tools for vulnerability scanning were identified and a Kali Linux box which has these tools installed. Kali Linux is a Debian-based Linux distribution aimed at advanced Penetration Testing and Security Auditing. Kali contains several hundred tools aimed at various information security tasks, such as Penetration Testing, Forensics and Reverse Engineering (Kali Linux, 2015).

A honeypot box was setup at the KENET data centre. The honeypot consists of data that appears to be a legitimate part of the KENET sites but is actually isolated and monitored, and that seems to contain information or resources of value to attackers. Once the attackers attempt to launch an attack on the honeypot, they are then blocked from accessing the entire KENET network.

A CERT portal was also developed at this stage. The purpose of the portal is to provide an online platform for disseminating information to the CERT members on issues such as current vulnerabilities with applications, protocols, popular content management systems and
operating systems. It also provide alerts and tips for securing systems and networks and simple how-tos for staying safe in the Internet.

All the existing systems at KENET were hardened to prevent or minimize the effects of future attacks. The web applications were installed with the following tools:

4.3.1 Modsecurity

ModSecurity is one of the Apache server modules that provide website protection by defending from hackers and other malicious attacks by having a set of rules with regular expressions that helps obstruct the processing of invalid data

4.3.2 Mod_evasive

Mod_evasive is an evasive maneuvers module for Apache to provide evasive action in the event of HTTP DoS or DDoS attack or brute force attack. It is also designed to be a detection and network management tool, and can be easily configured to update rules in ipchains, firewalls and routers.

4.3.3 Firewalls

All the servers installed at KENET were installed with host firewalls. The common firewalls installed include iptables, Packet Filter (pf) and ConfigServer Security & Firewall (CSF) firewalls.

4.3.4 Maldetect

Linux Malware Detect is a malware scanner for Linux released under the GNU GPLv2 license, that is designed around the threats faced in shared hosted environments. It uses threat data from network edge intrusion detection systems to extract malware that is actively being used in attacks and generates signatures for detection.

4.4 Stage 4 Operational phase

The services implemented in phase three were launched to the community and a mailing list created with membership of the staff in charge of security from the universities and research institutions served by KENET. Cyber security training curriculum for systems administrators and a computer security awareness training for users were developed.

Policies and procedures for operationalization of the CERT were developed and communicated to the community and the CERT portal was put on line. Penetration testing was done on the KENET systems using an external consultant, and the results and the process used documented.

4.5 Stage 5 Peer collaboration

KENET-CERT works closely with Kenya's National CIRT coordination center (CIRT/CC) as a sector CIRT for the academic institutions. Since KENET was already a member of the KE-CIRT, collaboration within the various sector CERTs in Kenya was already being practiced. Some of these sector CERTs include the banking CERT, the Telco’s CERT run by Technology Service Providers of Kenya (TESPOK), the police CERT among others.

KENET was also a member of various security mailing lists who share security updates on a regular basis especially whenever there is a breach of security anywhere in the world or when vulnerabilities are identified. They also share whenever breaches originate from the KENET network or when open proxies are identified within the KENET network or even when there are infringements in copyright issues originating from the KENET network. All these information is shared with the CERT members as soon as it is received.
5. KENET CERT Organization Model

The KENET CERT was developed using the Internal Distributed CERT model proposed by the European Union Agency for Network and Information Security (ENISA). In this model, an organization utilizes existing staff to provide a “virtual” distributed CERT, which is formally chartered to deal with incident response activities. There is a team leader who oversees and coordinates activities for the distributed team. Across the organization, individuals are identified as the appropriate points of contact for working as part of the distributed team based on their expertise with various operating system platforms, technologies, and applications; or based on their geographic location or functional responsibilities. The distributed team members can perform CERT duties in addition to their regular responsibilities or could be assigned to CERT work on a full-time basis (Killcrece, 2003).

The CERT serves as the single point of contact at KENET in relation to incident or vulnerability reports or activity for both internal and external parties. Using this model, the CERT was established using existing systems administrators and Engineers. This was deliberately done to reduce the cost of running the CERT. The following are the processes in the operation of the KENET CERT.

**Incident Reporting**

Incidences are reported either by email, the KENET support portal or the helpdesk support line and a ticket is created for all the requests. The CERT contacts are published at the KENET website and the CERT portal.

**Incident Handling**

A ticket is assigned to a CERT member who works to resolve the issue depending on the severity of the incident. If the incident is severe, the issue is escalated to the CERT team leader who sermons the entire CERT team who collaborate in solving the issue raised. If the incidence was raised as a result of a proactive activity such as vulnerability scan or receiving information from other CERTs, then the same is communicated to the KENET CERT community.

**Communication**

Communication is done through mailing lists both email and SMS when the CERT wants to pass general information to the community. This information is also posted on the CERT portal. When the information is specific to an institution, then the institution is called from the KENET line and an email send to the person in charge of security in the affected institution. Updates are posted on the KENET ticketing system and tracked until the ticket is closed.

6. CERT Implementation Challenges

Several challenges were encountered during the setup and implementation of the KENET CERT some of which are outlined below:-

- People who are trained and experienced in incident response techniques and practices are difficult to find.
There is no established education path for professional incident handling staff in existence as of today.

There was a lack of publicly available sample templates for policies and procedures for use in the day-to-day operations of a CERT.

There were few tools such as tailored help desk or trouble ticket solutions addressing the specific needs of the KENET CERT.

7. Impact of the KENET CERT

The effect of running a CERT at KENET is already being felt within the KENET community. Some of these effects are highlighted below:-

- Four Trainings have been conducted. These trainings focus on ways of securing the entire institutions infrastructure. These has led to better awareness and better setup of systems and a better knowledge of security threats and ways of mitigating these threats. A session on security has been included in all other KENET trainings.
- Information is disseminated in a timely manner. Universities and Research institutions receive timely information whenever vulnerabilities are identified.
- Quick resolution of security-related tickets because best practices have been identified, procedures developed and documented for the CERT team to follow during resolution.
- Reduction in the number of cyber security tickets
- Awareness and Discussion within the KENET community on cyber security is stronger now
- KENET has established Cyber security champions in each of its member institutions.

8. Conclusion

In any organization, whenever there is a computer security attack, an intrusion is recognized. It is important for the organization to have a fast and effective means of responding to such an incident. One way of dealing with such an incident is to establish a formal incident response capability or a CERT. This would ensure that when incidents occur, damage would be minimized, evidence preserved, quick and efficient recovery is provided. Similar future events are also prevented and the organization gain insight into threats facing it.

NRENs in Africa can benefit by collaborating among each other on issues to do with security by establishing NREN CERTs that can be coordinated regionally as is the case in Europe and America.

References


Biographies

Kennedy Aseda

Kennedy Aseda is a Lead Network Operations Engineer at KENET and has been working at KENET since 2008. He holds a BSc. in Electrical & Electronic Engineering from the University Of Nairobi and is a member of Kenya's National IPv6 Task Force as well as National CIRT/CC.

He primarily works on KENET's core network and focuses on routing, switching and configuration backup of network devices, security and virtualization. He also has a passion in process automation of network tasks and notification.

Martin Njau

Martin Njau is a Systems Administrator at KENET with four years experience in systems design and administration. He has worked in the development and administration of the KENET CERT platform and automation of network monitoring tools for the Network
Prof. Meoli Kashorda is currently the Executive Director of KENET. He is also a professor of information systems at USIU University in Kenya with research interests in measuring the Institutional ICT readiness in developing countries, telecommunications regulation and broadband Internet as an innovation platform.

He previously served as Dean of the USIU business school in Nairobi and a
telecommunications expert in the Communications Appeals Tribunal of Kenya. He holds a BS degree in Electrical Engineering from University of Nairobi and a PhD in Electronic Systems Engineering from University of Essex in England.

**Ronald Osure**

Ronald Osure is an Applications Developer at KENET and has 4+ years of experience in application architecture, design and development methodologies. He has developed solutions to allow the KENET Network Operations Centre leverage on the various Open Source Technologies they use through integrations and customizations. He also works in the research and cybersecurity divisions of KENET.

Mr. Osure is a Certified Ethical Hacker (CEH) in cyber security. He did his Bachelors of Science degree from Egerton University (2011) and attended the Summer School of Networking at Indiana University in 2013 which focused on
Managing Science and Technology: the Mozambican Ecosystem

Marangaze Munhepe MUHLANGA\textsuperscript{1}, Solange Rito LIMA\textsuperscript{1}, Venâncio MASSINGUE\textsuperscript{2}, and João Nuno FERRIERA\textsuperscript{3}

\textsuperscript{1} Centro Algoritmi, Universidade do Minho, Portugal
\textsuperscript{2} Universidade Eduardo Mondlane, Mozambique
\textsuperscript{3} Fundação para a Ciência e a Tecnologia, Portugal

Email: mmunhepe@di.uminho.pt, solange@di.uminho.pt, venancio.massingue@uem.mz, ferreira@fecn.pt

Abstract
The Current Research Information System (CRIS) emerges as an embracing paradigm for managing the multitude of Science and Technology (S&T) components and players. Instantiating its concepts and directives in the S&T ecosystems of developing countries allows to save years of progress, bringing these countries directly to the European level regarding S&T management.

In this context, this article aims at discussing the challenges and strategies for the implementation of technological platforms for managing S&T, taking Mozambique and its NREN as the primary goal. By identifying and understanding the components of the Mozambican S&T ecosystem, we expect to foster science in developing countries and promote international cooperation.

Keywords
CRIS, Open Access, S&T Management, NRENs, Repositories

1. Introduction

In today's society, the stage of Science and Technology (S&T) of a country evinces its developing level. In this sense, despite being rich in natural resources, which could be considered an advantage for economic and social progress, the development of most African countries is still immature, largely due to the lack of qualified human resources, the economic dependence, and the lack of a consistent system for managing science, technology and higher education.

National Research and Education Networks (NRENs) play an extremely important role being supported by non-profit organizations whose mission is to provide advanced services to the research community and higher education. In the absence of a single model that can be applied to all NRENs, as well as its constitution and funds, creating a model of NREN must meet the reality of each country in coordination and collaboration at regional and international level. Deploying NRENs infrastructures has been an important step for fostering S&T in these countries; however, to become fruitful, advanced services oriented to S&T management need to be provided to the academic and research community.

The amount of information related to scientific knowledge has grown exponentially on the Internet. The communications paradigm of next generation networks resulted in a new
environment and a new challenge for science, facilitating not only the dissemination and sharing of knowledge, but also new models of doing science. The available technological tools enable broader cooperation, transparency and visibility of scientific production (Vu, 2011; Audretsch & Welfens, 2013). Currently, most of the scientific research is carried out using electronic format. The production of scientific documents, the collaboration between researchers, the publication of research results, are examples of the application of information and communications technology (ICT).

In this context appears the concept of Current Research Information System (CRIS), defined as an information system that stores and manages data related to the entire life-cycle of research. However, the implementation of technological platforms for managing S&T, cannot be decoupled from the research ecosystem of each country. Thus, by: (i) taking worldwide initiatives and the Portuguese experience; (ii) identifying and understanding the components of the Mozambican S&T ecosystem, this article is devoted to discuss the challenges and strategies for deploying technological platforms for managing S&T in developing countries, more particularly in Mozambique.

This paper is organized as follows: Section II presents and interrelates the issues for managing S&T, including the description of CRIS components; Section III discusses the challenges and trends of CRIS evolution; Section IV enters into the Mozambique research ecosystem, ending with a set of recommendations for fostering open science in the country; finally, in Section V, are presented the conclusions of this work.

2. Managing Science and Technology

Managing S&T involves understanding the issues related to the national scientific system, considering its players, general framework and relationships (Lundvall, 2009). The absence or ineffectiveness of S&T management services, such as technological platforms for submission of research projects or scholarships, scientific open access repositories and data centers, force researchers to tasks that absorb their time and may compromise the research itself. A crucial step is the usage of information systems to support S&T management.

In Portugal, the electronic applications submission system provided by the Foundation of Science and Technology (Fundação para a Ciência e a Tecnologia - FCT), the main funding agency for research in all scientific domains, working under responsibility of the Ministry for Education and Science, has advanced tools that allow the management of application processes, and the interactive and efficient monitoring of the entire projects life-cycle until their closure. In the case of the Portuguese NREN, for example, represented by FCT, the evolution of the network infrastructure enables the creation of projects supporting research and education services, one of the most important being the national repository RCAAP (Repositório Científico de Acesso Aberto de Portugal).

The concept Current Research Information System (CRIS) arises in this context, being defined as an information system that stores data on research carried out by organizations and researchers, usually related to projects under funding programs. CRIS can manage all relevant information directly related to research, starting with funding opportunities, through call and proposals, following the publication of winning proposals that will become active projects to be managed and monitored until completion. Such projects generate outcomes, resulting in scientific publications or other type of document or product (Clements, 2014; Simons, 2014). Managing S&T based on CRIS can bring the following benefit:
(i) offer to administrators and science managers tools that facilitate the evaluation and report of scientific practice;
(ii) offer to researchers and academic community tools for accessing and managing information about scientific activity;
(iii) facilitate to media professionals, technology transfer companies, civil society organizations and individual citizens the discovery of innovative technologies and ideas, promoting links between science and society.

In this sense, CRIS will provide information on publications resulting from research produced in an institution, and corresponding authors. More information can be obtained, as the activities, projects, departments, funds and portals that can provide information to researchers in order to increase the visibility of research results produced in the involved institutions. In more detail, CRIS components are described hereinafter and represented in Figure 1:

- **Academic expertise**: platform for collection, delivery and analysis of intellectual production, scientific and other curriculum information from national researchers, which should be promoted by the government entity that manages science. As examples can be cited the Lattes Platform in Brazil and DeGóis in Portugal.
- **Organizations database**: database of research and development projects approved through competitions annually open to all scientific areas or through calls targeting research in certain areas or specific topics.
- **Scientific equipment**: database of research infrastructures and equipment, especially research infrastructures of strategic interest for supporting scientific and technological advances and for enhancing the development and innovation capacity of the research community.
  - **Statistics**: science indicators.
- **Project database**: database of R&D projects; the portal allows to see the list of approved projects through competitions.
- **Grant management**: portal for submission of applications for individual grants, after registration in the Information System.
  - **Projects call**: portal for submission of applications for R&D projects, after registration in the Information System.
  - **Evaluation**: evaluation of research quality.
- **Outcomes/Outputs**: corresponds to the creation of technological platforms, specifically open access (OA) repositories that allow the deposit, access and sharing of knowledge of national scientific production results, publicly funded by policies and governmental/institutional mandates.
  - **Scientific journals**: another way of publication of scientific production in OA is carried out through OA scientific journals, i.e., Gold OA\(^{107}\).
  - **Research Data**: the data used in research must be deposited in a data repository\(^{108}\).

\(^{107}\) In the OA field, the Budapest Open Access Initiative (BOAI) defined two pathways to OA described as: (i) Green OA - where the authors through self-archiving must deposit their publications in a thematic or institutional repository; (ii) Gold OA - which refers to publications in OA scientific journals with peer review.

\(^{108}\) The new guidelines of OA launched under Horizon 2020 (EC, 2013), reinforce that data resulting from research, including the associated metadata necessary to confirm the results, must be deposited in a scientific...
3. New Trends for CRIS

The evolution of information systems for the management of scientific activity has evolved, mostly in developing countries with a vast human resource capacity in ICT. Currently, the European Union (EU) has been a major engine of the debate on the development, integration and interoperability of services and platforms for managing science.

3.1 OpenAIRE

One of the European initiatives related to OA is the OpenAIRE project, which is an integral infrastructure that allows the management of scientific publications, and the information associated with them, through a network of repositories. This project presents several advantages because it links the aggregated publications in the repositories with financing information and scientific data sets (Príncipe, 2014). To be more effective, the project also provides a service helpdesk and technical guidance to all partners involved.

In a regional panorama, projects such as OpenAIRE can benefit:
- researchers in the deposit and sharing of research results;
- national OA initiatives to establish, implement and align scientific data policies;
- repository managers to increase the visibility of content;
- policy makers and funders to monitor the results of funded research;
- managers of projects and science administrators to support the realization of reports, statistics and dissemination of research results;
- potential data providers wishing to explore the interconnection of their research.

3.2 EuroCris, CERIF

data repository, and the free access to bibliographic metadata related to the deposited publication (the terms of the funder, the action's name, the initials and number of the agreement, the publication date, the embargo period and a persistent identifier).
In the European context, the euroCRIS is a non-profit association that brings together professionals of research information and of CRIS area for “development and curation of the international standard data model for research information called CERIF: the Common European Research Information Format. The promotion of cooperation and exchange of expertise between stakeholders in the research information domain…” (euroCRIS, 2015).

In this perspective, the euroCRIS has developed CERIF, which is the standard model of storage and interoperability of research information, e.g., the research metadata. CERIF has the advantage of including all components of research information of CRIS and the ability to represent the relationships between entities that are semantically defined (Simons, 2014; Seo, 2014). The CERIF-XML is a language that allows the exchange of information between systems. The CERIF/CERIF-XML are recommendations to EU member states.

The CERIF model, illustrated in Figure 2, provides great flexibility and robustness because complex roles and date-limited relationships between the three major entities (in orange) can be expressed, and other entities can be linked by role/date relationships to any or all of these three major entities. As example, it is possible to convey information such as:

- researcher $x$ works for organizational unit $y$ which is a sub-unit of organizational unit $z$;
- publication $Z$ came from project $X$ which is a sub-project of project $K$;
- person $a$ is a reviewer of a result publication $b$.

In this context, CRIS allows to answer several questions, such as: How many PhD students took part in national research projects? In which countries did they obtained their masters degree? How many scientific papers have been published by author $a$ in 2014 as a first author?
3.3 Unique Researcher Identifiers and Bibliometrics

To facilitate disambiguation in the use of authors' names and automate links to research, the ORCID (Open Researcher and Contributor ID) organization, an international non-profit organization governed by the research community, has as main activity to provide the registration of unique identifiers for the researchers and academic community (ORCID, 2015).

The unique identifier ORCID iD allows identifying unequivocally each researcher and facilitates the recovery of its scientific production that is linked to other existing systems of authors identification, such as ResearcherID, Scopus Author Identifier, My Citations Google Scholar, etc.

In this way, ORCID iDs avoid ambiguity and disorder related to the names of the authors and avoid the dispersion of scientific literature by the same author (Thomas, 2015). The use of ORCID iD identifiers are already being adopted in the science management systems from various countries, editorial groups (e.g., Nature Publishing Group) and funding agencies (e.g., National Institutes of Health - NIH, FCT in Portugal), who seek to follow with recent directives on CRIS and OA.

In the case of EU countries, the use of ORCID iDs will allow:
- to implement a national repository, solving problems in communication and interoperability of national and institutional information systems;
- to integrate efficiently in national reporting systems researchers from foreign institutions who come to develop their activity, and allow national researchers to export easily their scientific production to the information systems out of the country;
- to obtain ORCID iD is free and simplifies bureaucratic processes, allowing only one record to be used to identify a researcher into multiple entities.

Regarding CRIS evolution, the study conducted by (Ilva, 2014) reports that one of the biggest challenges encountered is related to the coexistence of CRIS and repositories, since they have distinct concepts, however, the trend is the integration of these two systems, for their coexistence in future. Another important aspect to be considered is that, while the platforms for building repositories are open source platforms such as DSpace and ePrint, the main existing CRIS platforms are all based on proprietary systems. Nevertheless, there are CRIS open source development projects, still premature to say whether they will have acceptance by the community.

Taking into account the perspective presented on the new CRIS paradigm, at present, it appears that this trend of change appears to be more at European level, although it corresponds to more advanced systems for managing science (Ilva, 2014).

In this sense, it is important that developing countries or institutions with limited financial resources rethink on existing open source alternatives to create repositories and forms of integration and interoperability with existing CRIS systems. At interoperability level, the main CRIS data collectors are Academic expertise, Research portal, Outputs and Project database. The main data providers are Organizations database and Outputs.
4. Mozambique Higher Education and Scientific Research

Scientific research in Mozambique is still in its infancy. After independence in 1975 the number of trained teachers was insufficient to cover the needs of education and higher education in the country, and not kept pace with population growth. Currently, Mozambique has near 50 higher education institutions (18 public and 31 private). In the world ranking, Eduardo Mondlane University (Universidade Eduardo Mondlane - UEM) is the oldest institution of higher education in Mozambique and considered the best higher education institution in the country.

The ICT policy adopted in 2000 defines main objectives to combat poverty and improve Mozambicans life. Ensure the production and access to knowledge are some of the fundamental aspects of the ICT policy for Mozambique to become a relevant and competitive partner in the global information society. Only in 2000 emerged the ministry specifically dedicated to science and technology, now called the Ministry of Scientific and Technology, Higher Education and Professional Training (MSTHEPT), and a strategic plan was approved for scientific research in the country to support the development of the National Research System (NRS).

In addition, to support the development of research in Mozambique, in 2005 was created the National Research Fund (NRF), the main government agency responsible for funding research in Mozambique. The promotion of programs, projects and actions in the field of scientific research in accordance with the strategic priorities of the country are the main objectives of the NRF. From the NRF budget to support research projects, mainly resulting from external support, a large part of the investment is dedicated to the training of human resources.

To develop its activity one of the biggest initial challenges that the NRF faced was in terms of the quality of the proposals of the submitted projects that were too weak when it was launched the first call. This led the NRF moving forward with training in research methodologies and on preparing of project proposals aimed at teachers, researchers, technicians and innovators, who have given positive results in terms of quality and quantity of proposals. In this context, research has presented some progress in Mozambique and the evaluation carried out since its inception in 2006 until 2014 shows that NRF has funded 250 projects, demonstrating the interest in scientific research.

4.1 MoRENet

Under the Mozambique Science, Technology and Innovation Strategy (MOSTIS), launched in 2006 to strengthen the National System of Science, Technology and Innovation, began the project for the development of the country NREN, called Mozambique Research and Education Network (MoRENet).

The challenges for the effective implementation of MoRENet are enormous taking into account economic, social, technical, technological, and infrastructural aspects. In this context, there is still much to do and a great commitment and pressure to fully operationalise MoRENet.

The MoRENet project infrastructure is based on optical fiber and SDH-STM technology. In more detail, it has 5 PoPs and operates at 155 Mbps for backbone and 34 Mbps for institutions, with a 155 Mbps shared Internet connection. This project will connect more than 80 institutions across the country.
Until January 2015, the network has been installed, but only in Maputo city and only in 13 institutions, Internet being the only service provided. Actually, with a new contract with a new communications service provider (CSP), the links to other institutions in Maputo, including the wireless network, are being completed, and then will be completed gradually in the provinces.

Given this perspective, it has been made an enormous effort on the part of stakeholders to ensure that the project becomes a reality, although they detected the following difficulties in the agreements reached with the first operator responsible for MoRENet implementation:

- the lack of terminal equipment in the market, which must be imported, leading to delays in the project implementation;
- lacks of metropolitan optical fiber, which creates difficulties to carry the optical fiber to institutions;
- another aspect which undermines the proper functioning of MoRENet is related to the power outages, common in the country, which implies the creation of contingency plans for infrastructures and natural disasters.

4.2 Scientific Contents and SABER

The lack of budget in research and education institutions to provide international scientific contents in different fields supplied by publishers is a big challenge. The effort of UEM in this context, enabled through the INASP program with whom UEM has worked since 2001, regards the negotiation with international publishers for the access to journals and books without charge or at low cost price for Mozambican institutions. With INASP support, Mozambique can access 90% of the publications paying 10% of their real value.

The acquisition model of scientific literature through commercial publishers in Mozambique is not associated with the academy of sciences of the country. In this sense UEM is the national coordinator of the consortium of universities supported by the INASP project, (INASP 2009) (International network for the availability of scientific publications url: http://www.inasp.info/en/network/country/MZ/) being responsible for channeling the budget available for paying the access to publications for the institutions of higher education in the country. Currently all Mozambican institutions of high education, public and private, access about 23 000 titles. There are other organizations with programs supporting access to scientific literature from specific areas that Mozambique and other developing countries use, namely HINARI, for biomedical, OARE, in the environmental field and AGORA for agriculture.

The OA movement in Mozambique is recent, mostly driven by UEM initiatives that try to give visibility and preserve the academic and scientific production of national institutions. In order to collect, preserve, aggregate and index the academic and scientific production of higher education and research institutions in Mozambique, the multi-institutional repository SABER was released in November 2009. SABER repository is a common platform that integrates six member institutions, including the Judicial Training Center (JTC), the Higher Institute of Science and Technology of Mozambique (HISTM), the Eduardo Mondlane University (UEM), the Pedagogical University, Polytechnic University and the University of St. Thomas of Mozambique (UST). Although the institutions mentioned above are officially
integrated, SABER repository maintains scientific and academic documents produced or related with Mozambique from other institutions in the country (SABER, 2009).

Key aspects to the successful implementation of SABER repository are: the contribution in terms of resources from the then Ministry of Education, under the background of quality improvement and innovation; Sida/SAREC funding (Greenberg & Muchanga, 2006), the Swedish agency for international development; and the technical collaboration with University of Minho in Portugal, for setting up the repository in the chosen platform DSpace. Although being a multi-institutional repository, SABER is hosted in UEM, which is responsible for the technical support, and the administrative tasks related to the workflow of the deposit of documents. After near six years, SABER stores about three thousand documents, including teaching materials, monographs and dissertations. In more detail, UEM with near 97.77% of documents deposited, is the institution that contributes with the largest number of documents, and the remaining documents, 2.23% are related to JTC, Polytechnic University and Pedagogical University. The rest of institutions, although integrating the repository, have no contribution in terms of contents.

Another conclusion observed when analyzing the increasing number of documents in repository SABER, is that much of the contents, 2341 documents, are related to the period before the creation of the repository, as shown in Figure 3. This has involved a great job of the SABER repository team in the digitization of existing documents in physical format from previous years, even without existing national and institutional policies and mandates to promote OA in the country.

Figure 3: Evolution of SABER repository

4.3 OA Journals: the case of RC-UEM

Scientific journals play a crucial role in the generation and sharing of knowledge, and peer reviewing contributes to improve the quality of the publication system. With this frame, EMU created in 2010 the Scientific Journal of UEM (RC-UEM), a biannual OA journal aiming at presenting the results of Mozambique scientific production undertaken in national institutions of higher education and research. The journal covers eight specific areas: (i) biomedical sciences and public health; (ii) engineering, architecture, urbanism and technology; (iii) letters and social sciences; (iv) natural sciences and environment; (v) agricultural, forestry and veterinary sciences; (vi) science of education; (vii) legal sciences; and (viii) economics, management and development. The first series of RC-UEM were launched in 2012. Whilst its importance is recognised, RC-UEM project faces numerous difficulties due to the research landscape and quality of scientific production in the country.
For example, the 2013 call for papers resulted in 70 submissions, and 14% of approvals after peer reviewing process (involving national and international reviewers).

The main challenges faced by the RC-UEM and other endogenous magazines are mainly related to the following aspects: (i) the lack of a national scientific community and the geographic boundaries of existing research lead to a shortage of submissions. Most of Mozambican researchers work in cooperation with international institutions (for instance, involved in their MSc and PhD studies). Even when the students return to Mozambique, it is common to maintain the external link and publish their work abroad. This is one of the biggest barriers to the creation of a scientific community turned inward; (ii) facing the lack of contents, the few endogenous magazines “die” prematurely, after two or three series; (iii) the reviewing process takes too long to be completed, impairing the process of launching a magazine edition. Moreover, as previously stated, most of the submitted works are not accepted.

Facing this scenario and the absence of national and institutional policies for scientific journals in the country, UEM is committed to build its institutional policy of publication and to register RC-UEM in the African directory of scientific journals.

5. Proposed Model for Open Science in Mozambique

Considering the challenges that Mozambican institutions face in implementing national and institutional policies and mandates of OA, this section presents the proposal of an initial model for open science in Mozambique. This model, presented in Figure 4, inspired in the model of the Portuguese national initiative RCAAP (Mulhanga, 2014), takes advantage of the benefits of a supporting NREN to propose the creation of the following services:

- the Hosting Repository Service for all institutions, so that they do not have to worry with the technical aspects related to the implementation of repositories, such as servers, connectivity, maintenance, backups, upgrades, monitoring, alarms. The national repository of Mozambique SABER should provide centrally the tasks related to the management and operation of repositories, and the member institutions only have to worry about the management of their documents (workflow and deposit).
- the Common Repository, oriented to institutions that do not have their own repositories, for various reasons, such as the low number of publications. Excluding UEM, the five other institutions integrated into SABER repository could benefit from this service. This alternative will allow researchers and the academic community of these institutions to have a shared repository for depositing in OA the results of their work. An institution taking part of a common repository may in future evolve to its own hosted repository, when an increase of documents resulting from the academic and scientific production occurs.
- a Hosting Service of Scientific Journals should be considered, such as the RC-UEM, which institutions may use to create a journal and make the whole life-cycle, namely the launch of calls for submission of articles, the support of peer reviewing, the editing and processing of scientific data.
- facing the issue of curation and preservation of scientific data, aligned with the recent guidelines on OA, it is important to include one Scientific Data Hosting Service, so that data that led to the publication of articles can be consulted and re-used.

Another aspect to consider, taking the example of the Portuguese national repository
initiative to strengthen the visibility of OA scientific contents of Portuguese language, is the signing of a memorandum of understanding between the governments of Portugal and Brazil, which resulted in the aggregation of theses and Brazilian scientific production and dissertations available in Brazilian institutional repositories. Subsequently, it was also created the Luso-Brazilian Conference on OA (CONFOA) held annually and open to all interested in sharing knowledge and experiences.

![Model for OA in Mozambique](image)

Figure 4: Model for OA in Mozambique

Considering that there is much work to do for the proposed model to be successful, the following challenges and recommendations should be considered:

- the guidelines of the ministry of science and technology are not specific in terms of repositories and OA, just pointing out the need for dissemination of scientific knowledge. In this sense, it is important that higher education institutions, through the Rectors Council of the country, the Academy of Sciences, the Ministry of Science and Technology entities and MoRENet, to engage in the debate about OA to involve a larger number of institutions into SABER repository;
- most of university libraries do not have a librarian. The country must invest in training librarians and specially trained staff to support the academic community and to manage contents;
- A national team should be created for dissemination and training on OA, operating in the institutions in collaboration with other regional and international institutions, including the UbuntuNet Alliance which ensures effective implementation of OA in Mozambique;
- the collaboration at CPLP (the Community of Portuguese Language Countries) level on the issue of OA should also be considered. The team of UEM documentation services has participated in CONFOA, and has made efforts to become a membership. This has proved to be complicated by the need to establish memorandums of understanding between the governments. Currently, the FCT in Portugal showed interest in starting the initial collaboration through the organization of a workshop in Mozambique in 2016 aimed at training and debating the various issues related to OA and managing science;
- the NRF needs to create a database of researchers with unique identifiers, since this entity is responsible for financing research in Mozambique. It should also be rethought the most appropriate way to implement a management system of the curricula of researchers who may undergo an effective collaboration with institutions.
linked to similar projects, such as Lattes of Brazil and DeGóis in Portugal, for sharing experiences;
- for MoRENet, which is at the stage of implementing the network infrastructure and expanding the links to other institutions in the country, there is still the challenge of making an analysis of the network service quality levels, ensuring that institutions already connected may discard existing contracts with commercial operators, to ensure the reduction of investment costs previously held by them;
- in the context of UbuntuNet Alliance and African Union, it is important to rethink effectively and comprehensively about creating a regional platform that can support researchers and research results funded by their supported programs and projects, hosting not only documents in full text format but also the research data set. South Africa, being the country with the highest number of OA repositories, is also the only country that has implemented a data repository, the South African Data Archive (SADA) (Van Schalkwyk, 2014). These aspects underscore the need for sharing experiences among African countries that are at the forefront on the issue of OA, as South Africa and Kenya.

6. Conclusions
This paper has discussed the new trends and paradigms related to managing S&T components and players. The national system of higher education and research, in-line with strategies that contribute to develop science in a country, turn out to be significant in the current panorama, and NRENs play a crucial role in the provision of advanced services to the scientific and academic community. In Mozambique, as in any developing country, the issues related to OA and CRIS prove to be relevant and should be analyzed carefully. Therefore, this work has discussed not only the new directives for managing science but also has stressed the importance of NRENs and OA, making specific recommendations aiming at fostering the sharing and disseminating of the results of research conducted in Mozambique.

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Biographies:

Marangaze Munhepe Mulhanga is a PhD Student at the Department of Informatics, University of Minho, Portugal. In 2007 completed 5 year degree in Systems and Informatics Engineering and received her MSc degree in Computer Networks and Services Engineering in 2010, from the same university (including Erasmus Placement at University of Vigo – Spain). From 2006 to 2008 she worked as an ICT technical support (data and voice) in the department of network and telecommunications in a portuguese bank (i.e. Finibanco). Her research interests include national research and education networks, next generation networks, network monitoring and quality of service, ICT policies and regulatory aspects of telecommunication, and science and innovation management.

Solange Rito Lima graduated in 1992, received her MSc and PhD degrees in Computer Communications from the University of Minho, Braga, Portugal, in 1997 and 2006, respectively. She is currently an Assistant Professor in Computer Communications at the same University. Her research interests include multiservice networks and protocols, QoS, traffic control and monitoring issues in IP networks.

Venâncio Massingue, is a Professor at the Department of Mathematics and Informatics at Eduardo Mondlane University (EMU), Mozambique. Graduated in 1992 in electrotechnical engineering at EMU, he holds a Doctoral degree in ICT from the Technology University of Delft (TUDelft), Netherlands. From 1996 to 1998 he masterminded the development of the Mozambique ICT Policy and ICT Strategy that were later approved by the Cabinet. From 1997 to 2005 he was Vice-Rector at UEM and from 2005 to 2012 he was Minister of Science and Technology of Mozambique. In 1998, he received the UNESCO Albert Einstein Medal for Science and Technology.

João Nuno Ferreira completed in 1991 the 5 year degree in Systems and Informatics Engineering at University of Minho, Portugal. In 1993 completed the Data Communications, Networks and Distributed Systems MSc at University College London. In 2003 completed an MBA at Porto Business School (UPBS). Between 1991 and 1993 worked as an ICT specialist at Department of Informatics, at University of Minho. Between 1997 and 1998 was also teacher at Atlântica University, Portugal. On October 1993 joined FCCN, as Technical Manager. In this period was responsible for a wide range of networking services and national and international projects. Recently the main focus of activity has been the connectivity services and projects of Rede Ciência, Tecnologia e Sociedade (RCTS), namely the implementation of a fiber optics network. Additionally has developed this platform for the advancement of Science and R&D in the context of the European research networks and the GÉANT network. On December 10th 2013, was appointed Member of the Board at
Fundação para a Ciência e a Tecnologia IP, the science funding agency. He’s responsible for all ICT related activities. On January 11th 2013, was appointed President of the Board of Directors at Fundação para a Computação Científica Nacional (FCCN).
Eduroam implementation: Case Study
Kenyatta University

Maureen Wanja NJUE
Kenya Education Network, Jomo Kenyatta Memorial Library, Local Project Offices, University of Nairobi, P.O.BOX 30244,0100, Nairobi, Kenya
Tel: +254 732 150500, Email: mnjue@kenet.or.ke

Abstract
Kenya Education Network, (KENET), is the National Research and Education Network (NREN) of Kenya. KENET is licensed by the Communications Authority of Kenya (CA) as a not-for-profit operator serving the education and research institutions. KENET provides affordable, cost-effective and low-congestion Internet bandwidth services to member institutions in Kenya. One of the services KENET offers is eduroam. This is a service that enables students and faculty wireless users registered in the home institution use their credentials in an eduroam service provider institution. Thus the student and faculty will not have to contact the service provider institution for access to the eduroam wireless service. KENET worked with Kenyatta University to deploy eduroam on campus. Kenyatta University is one of the public universities with a population of approximately 60,000 students. KENET was the project manager during the implementation of the project. This involved developing the tender document and technical specifications, evaluating the tender and overseeing the implementation of the Campus WLAN. KENET configured eduroam for authentication against MYSQL database. This was an extension of the existing campus wlan from a previous installation of just 8 access points to 142 access points. This paper will highlight the eduroam implementation process and the challenges that were experienced during the implementation. The paper will also describe the campus infrastructure for both the wired and wireless LAN, the uptake of eduroam on campus and the challenges that were encountered as eduroam was being promoted on campus.

Keywords
eduroam, campus wlan, database authentication, wireless, wlan

1. Introduction

Kenyatta University is located 16 kilometres from Nairobi City along the Nairobi-Thika highway and is set on over 1,000 acres. Kenyatta University is a public University with over 60,000 students offering a variety of courses in different disciplines. Kenyatta University also has a number of campuses across Kenya. With the vast number of students, it is important that the University ensures that the students have access to the University resources and Internet. Thus the University felt the need to extend the campus WLAN to ensure the students have access to Internet. More importantly the University saw the need to implement eduroam, ensuring the students and faculty have access to resources whenever they visit an institution that provides the eduroam service.

Kenya Education Network, (KENET), is the National Research and Education Network (NREN) of Kenya. KENET is licensed by the Communications Authority of Kenya (CA) as a
not-for-profit operator serving the education and research institutions.

KENET provides affordable, cost-effective and low-congestion Internet bandwidth services to member institution campuses in Kenya. We have set up a gateway to the advanced e-infrastructures for research that are available exclusively within the Research and Education Community anywhere in the world. We also provide shared services such as: co-location of servers, dedicated Virtual servers for e-learning systems, video and web conferencing, and capacity building for technical staff. KENET is the Computer Emergency Response Team (CERT) for the academic community. KENET also offers eduroam as a service and is the National operative body for eduroam in Kenya. KENET promotes use of eduroam across its member institutions and was able to work with Kenyatta University to provide eduroam services across campus for the students and faculty.

2. What is eduroam?

eduroam stands for education roaming, allowing students and faculty from a registered institution to access internet services in another institution offering the eduroam service. The Student/Faculty does not have to bother the visiting institution ICT Department by asking for credentials to access the wireless LAN. The student/faculty username and password is preconfigured on their laptop and all they have to do is open the laptop and join the eduroam WLAN service at the visiting institution. Each institution offering the eduroam service is expected to adhere to the KENET eduroam policy (http://eduroam.ac.ke/kenet-eduroam-policy.pdf)

Figure 1 : How eduroam works

3. Project Background

KENET received funding under the KTCIP/ Kenya ICT Board infrastructure grants and successfully implemented pilot campus wrlans in ten (10) member institutions in 2012. Most of the institutions did not have a proper campus wlan. The project was designed to give the institutions a taste of campus wlan and motivate them to grow the campus wlan. Kenyatta University was one of the beneficiaries of the project.

At Kenyatta University the campus wlan composed of 1 cisco 5508 WLAN controller, 1 server (RADIUS server), 5 cisco 1552e outdoor access points and 3 cisco 3500 indoor access
points. The project implementation was completed in early 2013. KENET configured the controller and RADIUS server. eduroam was configured to authenticate against MYSQL database.

4. eduroam implementation

In October 2014 Kenyatta University decided that they would like to expand coverage of eduroam on campus. This was a result of many factors including: demand from the students and campus wireless security - with eduroam there is AAA (Authentication, Authorization, Accounting), thus they would be able to know who is currently connected on their wireless LAN. Kenyatta University contacted KENET to assist in redesigning the campus WLAN to cover more areas on campus. The project was to cover areas where the students gather and study.

4.1. KENET's Role

A meeting was scheduled where Kenyatta University highlighted their needs and areas where they would like KENET to advise on. It was agreed that KENET will offer the following services:

I. Site survey: This involves having meetings with the Kenyatta University team, carry out site survey and take necessary measurements.

II. Report preparation: The reports include campus wlan proposal, detailed scope of works & bills of quantities.

III. RFP and tender document preparation.

IV. KENET was part of the tender evaluation committee.

V. KENET was part of the technical negotiations: This involved meeting both the contractor and Kenyatta University ICT Team to discuss the technical aspects of the project, discuss and agree on the implementation schedule and agree on a responsibility matrix.

VI. KENET supervised the campus wlan implementation: This involved having constant site visits to review the progress of the project.

5. eduroam implementation

Kenyatta University installed an additional 142 access points. This was 130 cisco aironet 1702 indoor access points and 10 cisco 1552 outdoor access points. The access points were installed in 39 different locations across campus. As the access points were being mounted across campus, one of the indoor access points was stolen. This resulted in having all the access points being unmounted until the physical security of the access points was reviewed. This resulted in the design of cages that would secure the access points.
Figure 2: Physical security of access points

Figure 2 above shows the cages that were designed and implemented. Kenyatta University then proceeded to update the student database and ensure all the students had an account to access eduroam. The students and faculty were alerted to start using eduroam as the other ssid with passphrase will be disabled.

6. Impact

On completion of installation and configuration of the additional 142 access points, there was a noted increase of wireless users on campus.

![Figure 3: the sharp increase in associated devices from the initial setup of users. From having minimal users on eduroam to having over 3200 devices associated to the eduroam ssid.](image-url)
The students were able to access resources from different locations due to the widespread coverage across campus.

7. Challenges
The following challenges were experienced during the implementation of the project:

I. Access point security: This is in regard to the physical security of the access points. One access point was stolen during implementation and this resulted in having all the access points unmounted until a solution was found. This resulted in constructing of cages to securely mount the access points using roll bolts. Figure 2 shows how the indoor access points were secured using cages.

II. Project delay: The project implementation was supposed to take 60 days; however it took close to a year to complete. The project experienced a number of delays for the following reasons: delay in receiving equipment, having to redo installations in some areas, construction of cages to secure the access points.

III. Lack of proper project management skills from the contractor.

IV. Challenge in updating the database when students and faculty request a password change.

8. Conclusion
eduroam was successfully installed on campus. The students can now access secure wireless across campus.

9. Recommendations
Kenyatta University will need to invest in deploying eduroam across its other campuses thus enabling the students to roam from one campus to another. The other access points not on eduroam need to be configured to eduroam.

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Biography

Maureen holds a Bachelor of Science Electronic and Computer Engineering from Jomo Kenyatta University of Agriculture and Technology and is also CCNA certified. Maureen joined KENET in 2008 as an intern and was eventually employed as an Assistant Systems Administrator.

Maureen mainly focuses on Campus networks design and implementation. This includes both LAN and Wireless LAN design and implementation. Maureen is the lead in implementing eduroam in Kenya and also is the lead in the training services offered by KENET to member institutions. Maureen is also the lead in the KENET training program.
Structuring and implementing the Brazilian Academic Cloud: strategy, modelling, challenges and services

José Luiz RIBEIRO FILHO\textsuperscript{1}, Antônio Carlos Fernandes NUNES\textsuperscript{1}, Ricardo NOBUYOSHI DOS SANTOS. MAKINO\textsuperscript{1}, Gorgonio BARRETO ARAÚJO\textsuperscript{1}, Graciela MACHADO LEOPOLDINO MARTINS\textsuperscript{1}, Leandro Marcos DE OLIVEIRA GUIMARÃES\textsuperscript{1}

\textsuperscript{1}Rede Nacional de Ensino e Pesquisa (RNP), Rua Lauro Müller, 116 sala 1103, Botafogo 22290-906 Rio de Janeiro, Brazil

Tel: + 55 21 2102-9660, Fax: + 55 21 2279-3731, Email: jose.luiz@rnp.br, antonio.nunes@rnp.br, ricardo.makino@rnp.br, gorgonio.araujo@rnp.br, graciela.martins@rnp.br, leandro.guimaraes@rnp.br

Abstract

This paper presents an overview of the strategies currently adopted by some National Research and Education Networks (NREN) to implement and offer scientific cloud computing services. It describes the constraints, opportunities and the strategy chosen by the Brazilian NREN – Rede Nacional de Ensino e Pesquisa (RNP) to plan, deploy and operate cloud services to and in collaboration with Brazilian public universities and research institutes. The hybrid, community and federated strategy was chosen as the most flexible and suitable for the current Brazilian NREN operation and funding models. It describes the cloud services that are in production or in a pilot phase, their status and next steps planned. Cloud service planning, deployment and operation are discussed, the alternatives considered and the chosen options. At the end, the cloud services deployed by RNP are presented and discussed, considering the technologies and benefits to the academic community in Brazil.

Keywords

cloud strategies, scientific cloud, cloud services, research and education network, hybrid and community cloud, federated cloud.

Introduction

The Brazilian National Research and Education Network (NREN) – Rede Nacional de Ensino e Pesquisa (RNP)\textsuperscript{109}, is the organization that plans, designs, deploys and operates a nationwide networking infrastructure under a contract with the Ministry for Science, Technology and Innovation (MCTI). A governmental program that currently includes four ministries – MCTI, Education (MEC), Culture (MinC) and Health (MS) defines, on an annual basis, the contract objectives and its funding. The program governance committee represents the four ministries, which supervises the program’s execution. Among the program’s objectives are the connections of university, research institutes, hospitals, museums, and many other public Research and Education (R&E) institutions through RNP’s nationwide network infrastructure – Rede Ipê, shown in figure 1.

\textsuperscript{109} RNP - the Brazilian National Research and Education Network (NREN) - http://www.rnp.br.
Besides connecting more than 1.300 points, of around 350 public and private institutions (universities and research institutes) through an advanced multi-gigabit national backbone, and more than 41 metropolitan area networks (through owned infrastructure\(^\text{110}\)) connected over more than 2.100 km of optical cables. RNP also offers advanced services on top of this network, potentially benefiting more than 3.5 million users. Advanced services include VoIP, web conferencing, video conferencing and telepresence rooms, video on demand (VoD), live streaming, federated authentication for most of the services and eduroam. RNP also hosts in its data center several partner institutions’ strategic applications such as the *CAPES Portal de Periódicos* – a federated web portal that offers access to a large variety of international scientific journals to all public universities in the country.

![Figure 1: RNP’s national network backbone – Rede Ipê.](image)

One of the main goals of RNP’s mission is to provide those and new advanced Information and Communication Technology (ICT) services to the Brazilian academic community. To achieve this goal, RNP is permanently seeking new technologies, products, services and processes, through partnerships and collaboration with the academy, industry and the world’s leading NRENs.

The ever-increasing production of scientific data (e.g. environmental monitoring, biodiversity data bases, a variety of simulation and visualization systems like climate forecast, high energy physics data collection, astronomy and cosmology), cultural related data (e.g. historical and rare collections, audio-visual content, also as a means of data preservation) and management data (e.g. government ICT policies and R&E programs execution, assessment

\(^{110}\) **REDECOMEP** (Metropolitan Community Education and Research Networks) – a fiber optics infrastructure build by RNP in more than 35 cities to connect R&E institutions to RNP’s backbone - http://www.redecomep.rnp.br/.
and management indicators, data bases and big data processing) requires a scalable, sustainable and high available datacenter infrastructure to support the demands. These facilities must be located in a distributed way and in places that provide telecommunication, energy and security services, as well as appropriate physical space/infrastructure. For most of the mentioned demands, cloud computing technology and services offers a cost effective solution.

This paper presents the strategy defined by RNP to plan, deploy and operate cloud services to and in collaboration with Brazilian public universities and research institutes. It is also describes the cloud services that are in production or in a pilot phase. The overall strategy is explained in the next sections, starting with a brief survey of current cloud strategies and services adopted by other NRENs. After that, cloud service planning, deployment and operation are discussed, taking into account the alternatives considered and the chosen options. In the last section, the cloud services deployed by RNP are presented and discussed, considering the technologies and benefits to the academic community in Brazil.

NRENs Cloud Strategies
The first step was a survey that looked at what other NRENs have been planning and doing, regarding their strategies about cloud computing services and infrastructure. Many NRENs are already offering cloud services in a variety of degrees and through different business models. However, in Europe, the Trans-European Research and Education Networking Association (TERENA/GÉANT Association) has been following closely the European NRENs strategies to offer storage/cloud computing services and infrastructure. Its annual TERENA/GÉANT Association Compendium (Terena, 2014) presents comprehensive information about all European and other NRENs in the world, where one can see how cloud computing deployment and services are evolving over time. Besides the annual compendium, TERENA also publishes studies produced by its working groups. A 2011 green paper which discussed the European NRENs strategic perspective on storage and cloud computing [2] was very influential in RNP’s own cloud strategy definition, presented here.

The study considered two basic scenarios:

a) Universities and higher education institutes outsource services to public clouds or to their NREN
b) NRENs and research organizations outsource services or sub-services to public clouds; and a question to a panel of experts – “What kind of services, sub-services or functions can be outsourced by Universities and/or NRENs to public cloud service providers, how, and under what conditions and circumstances?”

The panel discussed issues such as privacy, application types (commodity and specialized), data protection, risks, costs, thrust (on public commercial providers x NRENs) and the conclusion was as follows:

- The outsourcing of commodity application services (e.g. student e-mails and document sharing) from universities to public clouds can be done with low risk. Moreover, significant cost benefits can be achieved through a NREN coordinated and centralized contracting process.
- For infrastructure related services (e.g. computing and storage) outsourcing to public clouds, it was considered that the risks concerning service operation, data protection, authentication and access control were an issue for individual
universities. However, outsourcing these services to NRENs were considered acceptable, due to the established relationship and thrust between NRENs and universities.

- In case of the NREN itself, the outsourcing of commodity application services (e.g. calendar system) to commercial clouds seemed straightforward.
- Finally, for infrastructure related services (e.g. network operation, storage, videoconferencing, computing), the mixing of the NRENs own infrastructure with public clouds was considered a value-added IaaS scenario.

Figure 2: Cloud strategy decision tree.

Figure 2 shows a simplified strategy decision tree for NRENs that came out of the TERENA discussions (Szegedi, P. 2011) Regarding application services, NRENs can develop and provide their own services or can exploit the joint buying force of their users and brokering towards commercial cloud service providers. Regarding infrastructure services, NRENs can build their own cloud infrastructure or can aggregate user demands and channel them in to commercial cloud infrastructures.

Based on user demands, networking capabilities, funding schemes and the above conclusions, NRENs have adopted three major national deployment strategies for e-infrastructure services offerings:

- Building private storage/cloud infrastructure on top of the national R&E network;
- Connecting public (commercial) storage/cloud infrastructure via the national R&E network;
- Creating hybrid storage/cloud infrastructure (a mix of public and private
infrastructures) connected via the national R&E network.

At the end of 2012, as a result of “A Study on the Prospects of the Internet for Research and Education (ASPIRE)” form TERENA - a foresight study for exploring the implications of potential developments of the Internet up until 2020 and assessing their impact for the Research and Education networking community, the results of “The Adoption of Cloud Services” (ASPIRE 2012) was published. This study was another important resource to RNP’s own cloud strategy.

Finally, in 2014, at the TERENA Networking Conference 2014 (TNC2014), the Ireland’s NREN (HEAnet) presented its cloud strategy (Boyle, B. et al, 2014), which showed interesting similarities with the strategy planned by RNP, strengthening some points that were our plans or already under development.

The next section presents RNP’s cloud strategy, as planned and under deployment, based on the strategy alternatives already discussed in this document.

**RNP Cloud Strategy**

The cloud services/infrastructure strategy chosen by RNP came out of a process, which was guided and constrained by the demands of the Brazilian R&E community, RNP operation and funding models, as explained above, as well as other NREN cloud strategies also discussed in the previous section.

Additionally, four main stakeholders that play major roles in the strategy definition and implementation were identified: public R&E institutions (universities and research institutes), research groups, RNP and R&E funding agencies. The Brazilian academic cloud strategy was then built around those stakeholders’ requirements. The R&D institutions can be, at the same time or separately, customers and providers of infrastructure and services. RNP has the coordination role, being responsible for the cloud architecture definition, contracting and operating its services, to develop and deploy applications, and the coordination of the partnerships with other stakeholders. The research groups contribute with their scientific application’s requirements as well as with the development of new functionalities and the cloud funding, through and proportionally to their use of the national cloud. Finally, the strategy includes the R&E funding agencies to help them promote a change in the current research-funding model. The proposed funding model will take the portion of the money granted to research projects, destined to ICT infrastructure (including servers, storage and networking equipment, basic software and even some specialized applications), and transfer it directly to a National Scientific Cloud Program. Instead of having to build a usually expensive and fragile ICT infrastructure, which also takes time to buy and deploy, granted projects would receive an equivalent quota of the required platforms as services from the national scientific cloud.

Another dimension considered in our work pointed out to two main classes of user profiles: institutional users (represented by IT managers of R&E institutions) and individuals (e.g. researchers and their labs). These two user classes have specific requirements for cloud services and infrastructure, which can be grouped according to the three layers of cloud services: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). Institutional users demand mainly SaaS services such as staff e-mail, student registration, ERP platform and storage/backup services. They may also want to mirror some
parts of their local IT infrastructure to a private cloud, like virtual machines and block storage, corresponding to the IaaS service. On the other hand, research groups show the desire to have more control over the cloud infrastructure, therefore requiring mainly an IaaS service, which allows them to develop, test and run their own applications and services on top of a virtualized infrastructure (e.g. processing, storage /backup and networking). They might also need PaaS services to deploy applications and databases in a fast way, where collaboration projects using wiki, distributed version control system (DVCS), are some examples. Besides these two user classes, RNP itself can migrate most of its current advanced services to the cloud infrastructure, including VoD/media streaming, web and videoconferencing, and some of its partners services like the CAPES Portal de Periodicos\footnote{http://www.periodicos.capes.gov.br.} scientific journal web portal.

Because of the above-described “environment” and NREN’s major national deployment strategies for e-infrastructure services, discussed in the previous section, the best strategy that emerged for RNP’s cloud service/infrastructure was a hybrid, community and federated cloud, shown in Figure 3. The hybrid model allows RNP to act as a public (commercial) contract broker for “low risk” services, such as student e-mail, collaboration, etc. Through the community model, universities and research institutes can offer their own data center infrastructure (in full or partially) to the national cloud. They should be able to dynamically change the amount of resources shared with the national cloud and receive privileged access to other partner’s infrastructure (virtual processors and storage) in return. Finally, the federated model ensures the required level of security and trustiness among all the partners as well as to the users through RNP’s federated services. This strategy is also an answer to the geographical distribution requirement for a redundant and reliable cloud, once the partner institutions are distributed nationwide.

Figure 3: RNP cloud strategy.
The strategy also includes other definitions such as an Acceptable Use Policy (AUP) for the national cloud, the basic operation model (required to all partner institutions), the national cloud sustainability model, user interfaces and APIs, application migration support, to mention a few. Another concept defined in RNP’s cloud strategy is the shared data center component, the CDC (Centro de Dados Compartilhados). The CDC is a physical structure that hosts all required infrastructure for a Tier 2 datacenter, including redundant energy (also with power generators and UPS), fire detection and suppression systems, independent and redundant HVAC systems, unified management platform (that collects data related to temperature, humidity, smoke, etc.), and access control systems. RNP has already installed two CDC sites, one at Instituto Nacional de Pesquisas da Amazônia (INPA) in the North Region (Manaus/AM) (Centro de Dados Compartilhados é inaugurado em Manaus, 2014) [5] and other at the Instituto Federal de Educação, Ciência e Tecnologia de Pernambuco (IFPE) in the Northeast Region (Recife/PE) of Brazil respectively(Parque de Dados Compartilhados é inaugurado em Recife (PE), 2014) , as shown in figure 4.

To make this model work seamlessly to the users and partners, a middleware is required to provide an isolation layer between the cloud service user interface, as well as the application program interface (API), and the specific physical and virtualized resources offered by the community/federated infrastructure providers, including contracted public (commercial) cloud providers. This middleware is under development by some cloud computing research groups and the goal is to provide a high-level abstraction layer to allow the integration of resources, and let users access cloud services and infrastructure unaware of its management and operation details. On the other hand, when required, users should be able to choose where they intend run their virtual machines, host their applications, store and backup their files or move them from one cloud node to another, regardless of where the cloud nodes are geographically located. The challenge to implement these features nowadays derives from the high heterogeneity of cloud provider’s infrastructure and the lack of standards in the platforms.
Implementation and Service Definition

After the definition of the national cloud services and infrastructure strategy, RNP started in 2013 a pilot project, comprising the deployment of two container-based CDC. The platform is the Huawei IDS1000-A (All-in-one), at the INPA site and IDS1000-C (Cluster) at the IFPE site. The IDS1000 provides a flexible, mixing and modular design concept, committed to help customers to build green cloud computing data center infrastructure, and realize the availability, safety, agility, scalability and an optimal TCO. The IDS1000-A and IDS1000-C can grow horizontally or vertically providing a path for rapid infrastructure expansion. The Chinese company donated the datacenter infrastructure and the ICT equipment to the Brazilian government (Computerworld (2011)) The smallest configuration, installed in INPA, comprises two container modules: one with the HVAC systems, power generators and UPS system and the other hosts the ICT equipment. It currently has 132 physical processors cores and 0.6PB of storage. The other CDC has three container modules separated in HVAC systems, UPS and PDU systems and ICT equipment’s. Additionally, an external power generator was installed. It currently has 612 physical processors cores and 1.1PB of storage, as shown in figure 5.

![Figure 5: CDC (Centro de Dados Compartilhados) deployed at IFPE in Recife.](image)

Based on the already installed ICT infrastructure, considering the RNP cloud strategy and the types of users: institutional users (represented by IT managers of R&E institutions) and individuals (e.g. researchers and their labs), the process was started to design the cloud services that RNP can host and offer on these datacenters. The first step was to listen to RNP’s users and understand their needs and requirements for research and corporate services that the cloud services should provide. After that, the project team drew an implementation plan based on the most desired cloud services, as shown in Figure 6, considering their complexity, costs and knowledge required to implement, operate and support the services.
Based on the service implementation plan, RNP’s team made an extensive evaluation of available open source software and technologies to support and deploy cloud services. For virtualization platform, oVirt (oVirt, nd) and XenServer (XenServer, nd were considered, for the orchestration platform, OpenStack (OpenStack, 2015) and CloudStack (Apache, 2015) and cloud storage backend, like Openstack Swift (OpenStack Swift, 2015) and Ceph (Ceph, 2015) were also evaluated. RNP’s team based the evaluations on a list of requirements for each type of service, such as elastic computing, cloud storage, cloud e-mail, etc. The team also described some use cases for each service to facilitate the service modeling and prioritize requirements to develop or implement the services. Last, but not least, the team considered the legal aspects, which can affect public R&E institutions, like the Presidential Decree nº 8.135/2013 and the Interministerial Administrative Directive nº 141/2014 that impose public R&E institutions to host e-mail, VoIP, Web Conference and other communication services in organizations and entities of the Federal Government’s datacenters. Decreto nº 8.135 (2015) Portaria Interministerial MP/MC/MD no 141 (2014).

Additionally, some platforms developed by open source communities did not provide the requirements and quality which a NREN cloud services needs, like huge scale, federated authentication to mention a few. In order to solve these issues, RNP is working with research groups from universities to improve and accelerate the development and customization of open source solutions. For example, Big Blue Button(2015) which is a Web Conference platform, and OwnCloud (2015), a web front end to store files, had many improvements (most of the modifications returned to the community and were distributed in the open source version of these software). It is noteworthy that this action reinforces the commitment of RNP to the innovation and dissemination of knowledge.

**RNP Cloud Services Status**

Regarding the implementation plan, the first phase defined the Web Conference as the pilot service for 2015. RNP already had Web Conference service, but this service was based on proprietary software that had some license restrictions, constraints for the development of new features, and no flexibility to let this service “cloud ready”, so the decision was to develop a new service. To deploy this service RNP adopted a solution developed by a Brazilian research group called Mconf, shown in the Figures 7 and 8. The main goal of this project was to create a Web Conference system based on open source software with the
ability to interoperate seamlessly between computers and web-connected mobile devices with many new features (Mconf, 2015)

Figure 7: Mconf web conference interface.

The conception of Mconf comply with the RNP requirements of a cloud based Web Conference, such like:

- Self-service Model – users can create communities, manage other users on communities, delegate administration of communities, record and manage web conference sessions and more;
- Elasticity - Mconf was designed in a distributed architecture that are load balanced among datacenters in various points in the country which can be scaled up in an easy way;
- Accounting – all sessions and activities are logged, bringing accounting capabilities to manage the use and the health of the service.
Mconf has been running as a pilot service for RNP’s staff since October 2014. It will replace the old platform in 2016, with the expectation of being offered to institutions nationwide in 2017. During the pilot and experimental service many enhancements were implemented, such as a better user interface, a WebRTC\textsuperscript{112} module to improve the audio quality, a mobile app, etc.

In the second phase the pilot will deploy three services: Cloud Storage, Elastic Computing and Cloud e-mail. The first pilot to be deployed in 2016 is Cloud Storage, with Cloud Computing for Science (CNC) (Grupos de Trabalho da RNP ,2015) platform, a solution also developed by a research group funded by RNP. This service is divided in three parts:

- **Storage Backend** – composed by the nodes that will store user files and are responsible to guarantee file integrity, confidentiality and availability. OpenStack Swift\textsuperscript{113} was chosen to achieve these requirements.
- **Web Frontend** – will present the service to the user through the web, as shown in Figure 9. This frontend is based on the OwnCloud platform, but like Mconf, it was necessary to improve the open source code to meet the requirements and quality necessary to provide the service. To do this, another research group, also funded by RNP, made all the improvements, which is also being offered back to the community as our contribution.
- **Desktop and Mobile Apps** – the last part was to provide desktop and mobile apps. OwnCloud already has clients for most types of mobile and desktop operating systems, and these clients are ready to support authentication using the CAFe Federation\textsuperscript{114}, used to authenticate the RNP’s and academic community users. The only issue is that iOS client is paid. To solve this issue RNP developed a free iOS client to the academic community.

\textsuperscript{112} WebRTC is a free, open project that provides browsers and mobile applications with Real-Time Communications (RTC) capabilities via simple APIs. The WebRTC components have been optimized to best serve this purpose.

\textsuperscript{113} Swift is a highly available, distributed, eventually consistent object/blob store. Organizations can use Swift to store many data efficiently, safely, and cheaply.

\textsuperscript{114} The Federated Academic Community (Comunidade Acadêmica Federada - CAFe) is an identity management system that gathers Brazilian education and research institutions, through their databases integration.
CNC will start the pilot for RNP staff only in 2016, with an expectation to go as an experimental service in 2017. During the pilot and experimental service phases, the main goal is to correct bugs, identify enhancements to implement before going live to all users. They will also allow improve the security and finalize the integration between desktop and mobile clients with the CAFe Federation. The CNC user management interface is shown in Figure 10.
The second cloud service pilot planned to be started in 2016 is the Elastic Compute service, provisionally called compute@RNP, this service aims to provide virtual machines to the R&E community, allowing researchers to accelerate tests and simulations, which today depends of the acquirement of new hardware, which in some cases impact their research.

To achieve this, RNP defined some basic requirements to the platform that will support this service:

- **Self-service Model** - each user should be able to create, modify and destroy virtual machines, network and storage blocks at any time. This should be done through a Web Interface and/or via an API service, to allow and facilitate process automation.
- **Elasticity** – this service should be designed in a distributed architecture, which could be load balanced among participating datacenters and scale-up or scale-down in an easy way. These requirements should be extended to the users, so it will be possible to scale-up or scale-down virtual machines resources, virtual networks and storage space.
- **Accounting** – all sessions and activities should be logged to bring accounting capabilities to users and the administrators.
- **Integration** – the platform should integrate with other systems, allowing RNP to provide several services over this cloud platform, such as Cloud Application Hosting and others.

The service plans to start the pilot in the first half of 2016. RNP chooses Apache CloudStack as the software platform that will provide the service. It was chosen after a thorough evaluation of a list of requirements and a lot of discussion with the R&E community. The project team has ended the deployment of all systems and finished the test and homologation phase, as shown in Figure 11.
The service will support federated authentication by default, as shown in Figure 12, and will provide a variety of service offerings, like compute offerings since 1vCPU and 512MB of RAM to 6vCPU and 12GB of RAM, disk offerings from 10 GB to 2 TB of capacity, network offerings with firewall, load balance, DNS, NAT, VPN and others.

The third cloud service pilot planned to be deployed in 2016 is the Cloud e-mail service. This service is under construction and the main goal of the service is to provide a cloud based mail service that will allow the R&E community to host e-mail boxes to their staff, lecturers, researchers and postgraduate students. To achieve this goal, some requirements were defined:

- **Self-service Model** - each institution that subscribe the service will be able to set their own domain, manage their users, connect own LDAP database, manage spam white and black lists, customize their web interface for the users, manage message features like attachment size, etc.
- **Elasticity** – the service should be designed in a distributed architecture that is load balanced among datacenters and can scale-up or scale-down in an easy way, to guarantee high availability and integrity.
- **Accounting** – all sessions and activities should be logged to bring accounting
capabilities to users, administrators and also to RNP.

The Cloud e-mail service is planned to go pilot with some institutions at the first half of 2016. Currently RNP has defined the software platform that will provide the service. It was chosen after a careful evaluation of requirements that led to the Zimbra Enterprise (Zimbra, 2015) platform. The project team has ended the deployment of all systems and finished the test and homologation phase, as shown in Figure 13.

![Figure 13: Zimbra enterprise management dashboard.](image)

The next steps to start the cloud e-mail service pilot is to finish the business and management models and start to migrate the accounts from some R&D institutions to validate the processes and procedures and improve the service.

**Conclusion**

This paper presented a brief description of NREN's cloud strategies and the scenario chosen by the Brazilian National Research and Education Network, RNP, for the Brazilian academic cloud. The hybrid, community and federated strategy were chosen as the most flexible and suitable for the current Brazilian NREN operation and funding models.

The cloud implementation and services selected to be initially offered were presented, as well as their current status and next steps planned.

RNP believes that the Brazilian academic cloud will augment the security and the national sovereignty. It will also reduce current fragilities that many public R&E institutions demonstrate regarding the safety of an ever-increasing amount of strategic and vital information, as a consequence of a lack of adequate e-infrastructure services and support.

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**References**


Biographies

José Luiz Ribeiro Filho holds a Ph.D. degree in Computer Science from the London University, a M.Sc. degree in Computer Science from COPPE/UFRJ and is graduated in Eletronic Engineering at Universidade Federal do Rio de Janeiro. He started his career as researcher at Núcleo de Computação Eletrônica (UFRJ) in the 80’s, having taken part and leadership in several computer architecture and computer networks projects. Between 1996 and 2000 was responsible for the consolidation of the Brazilian National Research and Education Network (RNP). In the next four years José Luiz had activities in the private sector at Telemar and HP Brazil. Back at RNP in 2005, José Luiz was responsible for starting several national projects such as RedeComep and Rute, and lead the creation of the services and solutions area at RNP. He is currently the director of this area. He was counselor of the Brazilian Internet Steering Committee (CGI.br) in 1998-2000 and between 2011-2014, representing the academic community. He has also represented the country and RNP in various international forums.

Antônio Carlos Fernandes Nunes is MSc in Electrical Engineering at Federal University of Rio de Janeiro (COPPE/UFRJ), and graduated in Systems Engineering and Computer at Rio de Janeiro State University (UERJ). He joined RNP (Brazilian NREN) in May 1998 where he has worked in operations, administration and systems development. As Special Projects Manager of the General Directory he has led and worked on several projects inter-ministerial, and has driven the emergence and growth of the Federal Point of Interconnection Networks (FIX), and Coordinator of the Brasilia PTT Metro project in CGI.br, Supervisor of Midwest Community Networks for Education and Research project (Redecomep) and responsible for RNP’s Internet Data Center. Since 2009 he is Service Management Deputy Director of RNP being in charge of advanced services portfolio. He has
CCNA certificate, Relationship Marketing by Ibmec, and has published articles in the areas of networks, service management, technological innovation, and science and technology policies. He has also represented RNP in the ELCIRA project coordinating actions for AAI between the EU and Latin America, and promoting the deployment of eduroam services, and currently coordinates the RNP's actions in the MAGIC project (Middleware for Applications and Global Virtual Communities Collaborative) with global reach.

**Ricardo Nobuyoshi dos Santos Makino** is a computer Engineer and MBA in Information Security. Has a strong knowledge in cloud computing, cloud security and virtualization. Has a strong background in computer forensics, incident handling, web application security and network security. Nowadays, work as Cloud Computing Expert at RNP and is responsible for mapping demands related to strategic projects in cloud computing, manage and execute technical activities related to cloud, prepare feasibility analysis and technical advices to the executive staff. Additionally, help community projects like Cloud Security Alliance and ABNT (Brazilian Standard Organization) Work Groups for cloud computing and security standards.

**Gorgonio Barreto Araújo** is Solutions Management Deputy Director of RNP of the Brazilian National Research and Education Network (RNP). Master's degree in Administration by UFBA and Master and Bachelor of Science in Electrical Engineering from the State University of Campinas (Unicamp). He was Executive Director at Nexos Information Security, teacher of the Distributed Systems Laboratory (LaSiD) at the Federal University of Bahia (UFBA), and post graduation professor at the School Rui Barbosa (FRB). Gorgonio was Special Projects Coordinator and Information Infrastructure and Telecommunications Coordinator of the Information Society Program (SocInfo) of the Ministry of Science and Technology (MCT) / United Nations Development Programme (UNDP). Collaborated with the preparation of the Green Paper SocInfo. He was a consultant of the Ministry of Health (MOH) / United Nations Educational, Scientific and Cultural Organization (UNESCO) in the Project National Health Card (CNS). He was Network Engineer and later consultant RNP/UNDP, upon the implementation of the first Brazilian Internet backbone. Gave a series of extension courses from Unicamp, UFBa and Nexos in area Information and Communication Technology (ICT). It Leader auditor certified by IRCA in ISO / IEC 27001 is certified by EXIN ITIL Foundation.

**Graciela Machado Leopoldino Martins** is M.Sc. degree in Computer Science at Universidade de São Paulo (USP) and is graduated in Computer Science at Universidade Estadual Paulista (UNESP). She has a specialization in Strategic Management of Technological Innovation from UNICAMP since 2008 and is certified Project Management Professional (PMP) by the Project Management Institute (PMI) since 2013. She joined RNP (Brazilian NREN) in July 1998 where she worked with management.
Leandro Marcos de Oliveira Guimarães has been Service Manager of RNP since May, 2010. He is responsible for communication and collaboration services, identity management services and strategic hosting services, and currently is member of the GeGC (Global eduroam Governance Committee) and acts as secretary of the Latin American eduroam Committee. He has worked for over fifteen years in Information Technology areas, focusing on projects, planning and operation. He has an MBA in Project Management from IBMEC and another MBA in Information Security from IBPINET - RJ-FUNCEFET. He is certificated as PMP by PMI, COBIT Foundation by ISACA, the EXIN ITIL v3, Cloud Computing Foundation by EXIN and the MCSO (Modulo Certified Security Officer) by Modulo. With a Degree in Computer Networks from University Estacio de Sa, Leandro has worked in large companies such as Petrobras, TIM, Claro and Xerox Brazil. He has also managed RNP's activities in the ELCIRA project coordinating actions for AAI between EU and LA, and promoting the deployment of eduroam services, and currently manages the RNP's work package about platforms for mobility in the MAGIC project (Middleware for Applications and Global Virtual Communities Collaborative).
Virtual Research Environment for value-added services in national and regional NRENs: case studies

Ognjen PRNJAT, Ioannis LIABOTIS, Christos KANELLOPOULOS¹, on behalf of the VI-SEEM and MAGIC consortia

¹Greek Research and Technology Network, Mesogeion 56, Athens, Greece
Tel: +302107475683, Fax: +302107475683, Email: oprnjat@grnet.gr

Abstract
Case studies are presented for the role of national and regional NRENs beyond connectivity, encompassing computing (grid, cloud and High-Performance computing) services and big data management services. The case studies are the recently started VI-SEEM and MAGIC projects. The VI-SEEM project, started in October 2015, unifies the existing e-Infrastructures in South-East Europe (SEE) and the Eastern Mediterranean (EM), including Grid, cloud, and High-Performance Computing resources. It does so in order to better utilise synergies, for an improved service provision within a unified Virtual Research Environment (VRE) to be provided to the scientific user communities in this large region. The overall objective is to provide a user-friendly integrated e-Infrastructure platform for scientific communities in Climatology, Life Sciences, and Cultural Heritage for the SEE and EM regions; by linking networking, computing, data, and visualization resources, as well as services, software and tools. The Virtual Research Environment provides the scientists and researchers with the support in the full lifecycle of scientific research: accessing relevant data necessary for their research, using it with provided codes and tools to carry out new experiments and simulations on large-scale e-Infrastructures, and producing and integrating new knowledge and data - which is stored and shared within the same VRE. The project is founded on the service-oriented data-driven approach, where a specific set of activities deals not just with simple e-Infrastructure data storage (live, dropbox-like), but includes the support for the full data lifecycle for the 3 target communities. The value-added computing services provided to the researchers include grid and cloud computing, as well as large-scale High-Performance Computing platforms, with a set of management tools provided for the unified management of computing resources. All project services will be provided through a service catalogue. Similarly the MAGIC project, started in May 2015, aims to adopt a service-oriented approach to advertising specifically the NREN cloud services, and this approach will be implemented through a compatible service catalogue, based on the GEANT cloud catalogue: thus the envisaged MAGIC cloud catalogue is also briefly discussed.

Keywords
Virtual Research Environment, Service catalogues, Grid computing, Cloud computing, High-Performance computing, Data management.
1.0 Introduction

In the last decade, a number e-Infrastructure initiatives were crucial for enabling high-quality research by providing networking and computational resources, application support and training, in both South East Europe (SEE) and Eastern Mediterranean (EM) and have supported the European vision of inclusive and smart growth, based on knowledge and innovation, enriching the European Research Area. These initiatives have helped to reduce the digital divide and brain drain in Europe, by ensuring access to regional e-Infrastructures in total 20 countries in the region. National and regional networks have been set up, as well as national and regional computing platforms, providing different types of value-added computing services to NREN users and beyond.

The VI-SEEM project (https://vi-seem.eu/), started in October 2015, unifies these existing e-Infrastructures in SEE and the EM, including Grid, cloud, and High-Performance Computing resources. It does so in order to better utilise synergies, for an improved service provision within a unified Virtual Research Environment (VRE) to be provided to the scientific user communities in the this large region. The overall objective is to provide user-friendly integrated e-Infrastructure platform for scientific communities in Climatology, Life Sciences, and Cultural Heritage for the SEE and EM regions; by linking networking, compute, data, and visualization resources, as well as services, software and tools.

2. Architecture for integrated e-Infrastructure services

The integrated platform will encompass all layers including the networking and computing resources, and adding the specific data (and related data management services), software and tools relevant for the regional multi-disciplinary communities. The diagram below depicts this integration over layers across the 3 target communities.

![Figure 1 - VI-SEEM conceptual architecture](image)

Overall objective is to provide user-friendly integrated e-Infrastructure platform for Scientific Communities in Climatology, Life Sciences, and Cultural Heritage for the SEEM region; by linking compute, data, and visualization resources, as well as services, software and tools.
The detailed objectives include the following, also giving an indication of size of the infrastructure and the spread of its services.

- Provide scientists with access to state of the art e-Infrastructure - computing, storage and connectivity resources - available in the region; and promote additional resources across the region. Size of infrastructure – 21500 CPU cores, 325000 GP-GPU cores and 18500 Intel Xeon Phi cores of HPC, 2900 grid cores, 10500 cloud VM cores, 11 PBytes of storage (of which dedicated 5-15%, 10-15%, 5% and 10% respectively).
- Integrate the underlying e-Infrastructure layers with generic/standardised as well as domain-specific services for the region. The latter are leveraging on existing tools (including visualization) with additional features being co-developed and co-operated by the Scientific Communities and the e-Infrastructure providers, thus proving integrated VRE environments. The approach will be service-driven in terms of service components and definitions, and their invocations. 10 domain-specific services and 25 codes are envisaged.
- Promote capacity building in the region and foster interdisciplinary approaches, with minimum of 39 distinct applications and 45 research teams using the VRE.
- Provide functions allowing for data management for the selected Scientific Communities, engage the full data management lifecycle, link data across the region, provide data interoperability across disciplines: with minimum of 30 distinct data sets.
- Provide adequate user support and training programmes for the user communities in the SEEM region: 18 dissemination events organized by the project with total of 1000 persons targeted, 12 training events organized by the project with 300 persons targeted.
- Bring high level expertise in e-Infrastructure utilization to enable research activities of international standing in the selected fields of Climatology, Life Sciences and Cultural Heritage. There are 70 expected publications in project lifetime, 30 after project end, as well as 50 presentations at the selected events.

### 3 Scientific communities served

The initiative focuses on 3 distinct communities of crucial importance for the region. The breakdown of the types of the applications is shown in the table below, and the details of the communities and their use of e-Infrastructure services described further down.

<table>
<thead>
<tr>
<th>Climate</th>
<th>Life Sciences</th>
<th>Cultural Heritage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Climate Modelling</td>
<td>Modeling and Molecular Dynamics (MD) study of important drug targets</td>
<td>Digital Libraries</td>
</tr>
<tr>
<td>Global Climate Modelling</td>
<td>Computer-aided drug design</td>
<td>Interactive Visualization Tools</td>
</tr>
<tr>
<td>Weather Forecasting</td>
<td>Analysis of Next Generation DNA sequencing data and RNA profiling data</td>
<td>Semantic Referencing</td>
</tr>
<tr>
<td>Air Pollution/Quality</td>
<td>Data mining to identify prevalent diseases/mutations in the SEEM region</td>
<td>Image Classification</td>
</tr>
<tr>
<td>Model Development</td>
<td>Image processing for biological applications</td>
<td>Modelling of Built Environments and Advanced Representation</td>
</tr>
</tbody>
</table>
Visualizations, Datasets, etc. | Computational simulation of DNA and RNA | Scientific simulation of materiality and systems' properties
---|---|---
Synchrotron data analysis | Geo-referencing Tools | Bioarchaeology

The **Climate Modelling** and weather forecasting community has traditionally very strong computational needs. In particular, the integration of various computational resources such as HPC and Grid jointly with data infrastructure that is addressed in VI-SEEM greatly supports research and operational activity of regional relevance. The community targeted here is active in a wide range of research activities. Perhaps the largest focus is on regional climate modelling and weather forecasting, where local weather and regional climate phenomena are investigated. This is complemented by global climate modelling where the impact of global phenomena on the regional climate is the focus. The results of both are crucial to predict extreme weather in the region and understand the future trends of the regional climate. Another strong field of related research is the study of air pollution that includes the influence on the climate and human health. These activities jointly enable the assessment of the impact on regional climate due to climate change. Climate impact studies provide the analysis of the upcoming change on humans, the environment and society that is so crucial for policy makers. Complementing the research activities above are code development to help improving simulation methods and also visualization, which is crucial for the analysis of the enormous amount of data created in simulations, but also important for the communication of results to policy makers in particular and the wider public in general. The activities pursued based on tools to be provided through VI-SEEM have strong synergies, both geographically and thematically, and all require a neat integration of data and computing resources.

The Climate Scientific Community will specifically benefit from the combination of HPC and Grid computing jointly with the storage facilities as it heavily relies on data from very scattered locations. The VRE will collect a comprehensive list of commonly used databases and provide direct access where possible. Jointly with code repositories and training material for climate models, the VRE will create a highly productive working environment for Climate scientists from the 19 different research groups distributed over 13 countries. Additionally, some of these users have pledged to make accessible local data through the VRE. The data management provided through the VRE will enable the community to professionally host and share the data.

Regarding the **Cultural Heritage**, the SEEM region is renowned for its ancient civilizations. It is also an area of major socioeconomic and cultural developments during the medieval and early modern periods. In this context, the cultural heritage of the region is of central importance for the whole of humanity. Yet, these rich traditions and their study are under threat by contemporary political developments and conflicts. This Scientific Community aspires to invest in advanced computational tools in order to build an appropriate VRE for the collection and study of the historical artefacts and build scientific interaction that transcends ethnic boundaries and conflict. The current state-of-the-art of the field is that no common models and software platforms are developed due to the lack of access to the required resources and support. This limitation renders the users unable to explore the potential of bespoke software for big data applications, which is necessary for the establishment of universal platforms that would perform as cross-disciplinary test labs. This project can act as a catalyst in strengthening links among key players in the field bringing users currently working autonomously together. Great potential is identified for research groups that have
not used large scale computing before. Linking these to experienced groups will significantly improve productivity.

The project aims to improve the research capabilities of the CH community by providing access to an e-Infrastructure with critical components needed for the advancement of the field such as access to Cloud Infrastructure as a Service, data repositories and visualization. Given the wealth of the historical artefacts of the SEEM region, there is a demonstrated interest for researchers across Europe for integrated repositories and data access. This facility will promote collaboration not only among groups in SEEM but also with groups across Europe enabling ground-breaking research to be accomplished. Beyond the data needs, VI-SEEM will also facilitate the slow transition of the CH community towards computational more intensive activities. Examples for these trends are the high detail rendering of 3D modelling, and efforts to simulate environmental influence on historical buildings. The CH community also includes the combination of advanced content management systems and computational intensive workflows and querying. The training and user support program will be critical for the adaptation of advanced computational approaches by the CH community that is not as advanced as compared to the other two scientific domains. The established VRE will enable ground-breaking research in CH not only involving regional users but across Europe. We thus expect an increase in the number and quality of publications and presentations. The CH Scientific Community of VI-SEEM consists of 14 research institutes from 9 countries (including those outside the catchment area).

Regarding Life Sciences community, advances in computational infrastructure during the last decade have facilitated the development of biological data analysis for big data and computational biology as key research methodologies in both academia and industry. The use of computers in biology has enabled our better understanding of mechanistic aspects in health and disease and has accelerated the development of novel therapeutics. In this proposal, the Life Sciences Research Community is chosen because of its central role in achieving a higher quality of life in the SEEM region. The aim of the VRE is to create and provide the necessary services over a capable infrastructure to facilitate research for understanding of disease mechanisms in the SEE and EM populations. The overall goal is analysis of datasets by using integration of data within the VRE that could ultimately lead to regional characteristics that would assist the effort for developing personalized medicine in SEE and EM. Project participants and related institutes will assist in data collection and analysis, run and optimizing computational codes and using the research results to understand the molecular basis of diseases associated with SEE and EM areas with projections to develop personalized therapies. By bringing their own expertise into the consortium, the VRE partners will intersect their research interests in order to achieve the common goal in an interdisciplinary approach. Such an undertaking would require the use of computational resources for a) data production, b) data analyses, b) storage, d) visualization.

The exponential growth and availability of data from patients of the SEEM region and beyond have led to the “big data” era. Patient data sets are markedly large and complex, which renders their processing laborious using traditional data processing applications. The associated data analysis challenges include capture, curation, analysis, search, sharing, storage, transfer, and visualization. This trend to larger data sets is due to the additional information derivable from analysis of a single large set of related data, as compared to separate smaller sets with the same total amount of data, allowing correlations to be found in order to prevent and understand diseases. The participating countries have a keen interest to analyse and use big data for the understanding and prevention of diseases prevalent in the SEEM region. The cross border/cross region nature of human disease requires data and local knowledge sharing over a wider SEEM area: the LS Scientific Community of VI-SEEM
consists of 12 research institutes from 10 different countries of the region.

4. Technical activities

The activity on e-Infrastructure services provides the unified underlying state-of-the-art e-Infrastructure for the benefit of the Scientific Communities. The underlying components include networking, computing (HPC, Grid, Cloud), storage, and standard interfaces to these. Issues of dynamic provisioning, access to combination of resources for the same project/application, monitoring and accounting for different types of resources will be specifically tackled. Thus, integrated high-quality services will be provided to end users, by supporting the regional e-Infrastructure, fused with end-user VRE services.

Data Management Lifecycle activities deals with Data lifecycle support for VRE and Scientific Communities including data storage (live, dropbox-like), data archiving, data manipulation, collaborative access, domain specific interfaces to storage, data annotation and citation, metadata, PIDs, etc. All these are state-of-the-art services which will enable the users to conduct high-quality research with the relevant data. Semantic knowledge representation and ontologies will be used where appropriate to enable data reuse from different services and applications, thus ensuring knowledge sharing, separation of domain from operational knowledge.

The activity on “Domain-specific services and support” deals with domain-specific services in 3 target regional communities. These services include community-specific content management systems, workflow engines, collaborative tools, etc; as well as specific community-related codes, analysis tools and visualization components. This WP will provide the link for integration of these services with the e-Infrastructure backbone, and will be following the data management principles supported in the data activity. Finally, it will provide user support. The activity will gather together large number of data sets, codes, models and tools and fine-tune these to provide smooth and coherent VRE access to the end user. In this manner, it will both quantitatively and qualitatively improve the overall end-user perception of the underlying services provided by the project.

Overall, the end-user will be provided with a Virtual Research Environment which can be visualized in the diagram below.
5.0 Service management principles

The VI-SEEM project will adopt a full service-oriented approach, where all services offered and created by the project need to be included in a service portfolio/catalogue following the service portfolio management process as defined by FitSM (www.http://fitsm.itemo.org/) with the additions and fine-tuning that is required for the VI-SEEM environment. Two distinct tools need to be used/developed: the service portfolio/catalogue management portal and the configuration/service/resource registry. The service registry will be based on the similar design such as the GN3+ Cloud Service Catalogue (https://catalogue.clouds.geant.net) developed by GRNET.

Similarly, the MAGIC (http://www.magic-project.eu) project will build the service catalogue in order to advertise the NREN cloud services available in all world regions. It will also be based on the GN3+ Cloud Service Catalogue, which provides the Cloud Service Registration: a point through which the cloud providers can list their services: thus service operators will be able to register their services, and end-users will be able to find the offerings. The implementation provides view of Service providers, Services and Criteria per service. Edugain (http://services.geant.net/edugain/Pages/Home.aspx) or local account based authorization model is used for access. Components of the design of the current GN3+ Cloud Service are:

- Service Registry: central point for registering all the services with all relevant metadata associated with the services (e.g. type of service, endpoints, price information).
- Service Search: catalogue being searchable directly by end users. Users can login using their institutional credentials, but log in is not required for accessing the service. Users can see/search: services that are available to them through their IdF; services that are available to all the users of eduGain; services that are available on the platform but not to their IdF.
- Service Matrix: a single place with information for all the services available on the platform, displaying the relationships, in matrix form, between the services, the IdFs and the individual institutes.
- Service Map: a way to drill down to the services offered to a specific region.
- Service Rating: users can rate the service; ratings would not be anonymous. Comments accepted, and accessible to the respective SP.
- Service Request: users send requests to their IdF/Group/Organization for a service that is listed in the catalogue but is not available to their scientific community.

6. Conclusion

We presented a case study for the role of national and regional NRENs beyond connectivity, encompassing computing (grid, cloud and High-Performance computing) services and big data management services. The case studies are the recently started VI-SEEM and MAGIC projects.

The VI-SEEM consortium brings together partners from 16 countries, the majority of which are the NRENs also providing cloud Infrastructure-as-a-Service storage / Virtual Machines, Grid and High-Performance Computing value-added services. The partners join forces to provide a large regional unified Virtual Research Environment to be provided to the scientific user communities in Climatology, Life Sciences, and Cultural Heritage for the SEE and EM regions. The platform links networking, computing, data, and visualization resources, as well as services, software and tools. The Virtual Research Environment provides the scientists and researchers with the support in the full lifecycle of scientific research: accessing relevant data necessary for their research, using it with provided codes and tools to carry out new experiments and simulations on large-scale e-Infrastructures, and producing and integrating new knowledge and data - which is stored and shared within the same VRE. All project services will be provided through a service catalogue. Similarly the MAGIC project aims to adopt a service-oriented approach to advertising specifically the NREN cloud services, and this approach will be implemented through a compatible service catalogue, based on the GEANT cloud catalogue: thus the envisaged MAGIC cloud catalogue is also briefly discussed.

Overall these 2 projects are flagship examples how multiple NRENs within a large region can come together and share a number of value-added services for the benefit of their
international scientific communities.

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**Biographies**

Dr. Ognjen Prnjat holds the position of European and Regional eInfrastructure manager in the Greek Research and Technology Network. In this role he is responsible for organizing various aspects of computing infrastructures in the South-East European region and beyond, their sustainability and seamless integration in pan-European eScience infrastructure; as well as GRNET involvement in pan-European and worldwide eInfrastructures. In the past 10 years he has acted as project coordinator for 5 EC projects in the field. Previously Ognjen was with the Department of Electronic and Electrical Engineering, University College London, where as a Research Fellow he was leading technical and project management aspects of a number of EC ACTS/IST and UK EPSRC projects in diverse fields of computing and telecoms. He holds a Bachelor of Eng. Degree in Electronics and Electrical Eng. (First Class Honours) from University of Surrey, UK, 1995; MSc (Distinction), 1996, from University College London; and Ph.D. in Telecoms from UCL, 2001.

Ioannis Liabotis is a project manager at GRNET S.A. During his 8 years at GRNET he has been involved in a series of FP6 and FP7 eInfrastructures projects related to HPC, Grids and Cloud. He has been the technical coordinator of the SEE-GRID-2, SEE-GRID-SCI and HP-SEE projects. He is currently member of PRACE Council and member of PRACE project management boards representing Greece. He has managed open calls for HPC access in Europe (DECI) and South-East-Europe (HP-SEE), and has extensive knowledge of SLA management aspects in computing environments. He obtained his Diploma in Electrical & Computer Eng from NTUA, Greece, in 1998; and his MPhil in Computation from UMIST, UK, 2000. He is technical coordinator of the VI-SEEM project.

Christos Kanellopoulos has been involved in European and National research and infrastructure projects since 2000, serving in various technical and management positions. 2000-02 he was a team leader in the project CAMPUS of Lufthansa coordinating the infrastructure rollouts at the airports of Athens, Beirut, Paris, Venice, Vienna and Zurich. 2002-12 he was the technical coordinator of the Scientific Computing Centre at the University of Thessaloniki leading the activities of the centre in more than 15 FP6 & FP7 projects in the areas of Grids, Distributed Systems and HPC. During that period he served as a WP Leader, Activity Leader and Working Group chair in various projects and fora. Since 2012 he works at GRNET in the fields of Distributed Systems, Cloud Computing & Security. Currently he is the Product Manager for the ARGO Availability & Reliability Monitoring Framework, he is leading the eduGAIN - STORK Integration Pilot in GN3Plus and he is the Security Officer for NGI GRNET and the CA Manager for the HellasGrid CA and the SEE-GRID CA, which provides services as a Catch-All CA for EGI.
Multi-conference rooms: architectural and technological view

Valter ROESLER¹, Luiz COELHO², Guilherme LONGONI¹, Felipe CECAGNO³, Leandro CIUFFÔ², Renato DUARTE²

¹ Federal University of Rio Grande do Sul (UFRGS), F. +55 51 3308-6167, Email: roesler@inf.ufrgs.br, longoni@gmail.com
² Brazilian Research and Education Network - Rede Nacional de Ensino e Pesquisa (RNP), F. +55 21 2100 1010, Email {luiz.coelho, renato.duarte, leandro.ciuffo}@rnp.br
³ Mconf Tecnologia Ltda, F. +55 51 8109-7121, Email: felipe@mconf.com

Abstract
Meeting rooms, as well as classrooms, can be transformed in multimedia spaces that amplify collaboration and education. Computers, projectors, large displays, videoconference systems and wi-fi networks are examples of Information Technologies infrastructures commonly installed in modern rooms. However, the investment to transform a traditional classroom in a digital learning space must be spent efficiently to justify the invested resources. The cost of any physical space depends on how often it is used. For example, a US$100,000.00 regular classroom can cost more than a US$500,000.00 one. How? Suppose the cheaper room is used eight hours a month, while the more expensive one is used eighty hours a month. Over five years (or 60 months), the per-hour cost of the cheaper room will be US$100,000.00 / (60 * 8) = US$208.33, while the per-hour cost of the more expensive one will be US$500,000.00 / (60 * 80) = US$104.17, i.e., half the cost of the first. The bottom line is that keeping an idle physical structure has a high associated cost. The objective of this paper is to present an architectural and technological view of a new system called "multipresence" which adapts to various physical environment settings, and enables the interoperability of various technologies.

Keywords
Mobile conferencing; ultra-high definition; web conferencing; telepresence; multipurpose rooms.

1. Introduction
The spread of video conferencing systems has grown rapidly in recent years, and its use is currently quite common, preventing thousands of trips daily. The most common models are currently the videoconferencing room systems, telepresence, desktop, web conferencing and virtual reality. A more detailed view can be seen in Roesler (2012).

The problem arises when there is a need to interoperate all systems in the same conversation, using also an online integrated multi collaboration tool. For example, one would like to use a room system and collaborate with a fellow at home, and with other colleague using a mobile device, and with others through a telepresence room. All of them should be able to see each other, as well as exchange files, documents, images, among others.

Besides the technological aspect, the room should be able to adapt to different situations, i.e., there should be possible to rapidly change the physical layout of the room to cope with
different uses, increasing its occupancy rate and reducing its per-hour cost.

This paper presents the multipresence system, which deals with both physical and technological aspects of a multiuse room. In terms of applications, the proposed room enables local and remote classes, local and remote group dynamics, meetings in U, board meetings, among others, as seen in Figure 1.

![Figure 1. Different uses for the proposed room.](image)

Section 2 presents the physical view of the room, detailing how it deals with rapid layout changes. Section 3 presents the technological view of the room, detailing its architecture and functionalities. Section 4 presents the final remarks of the paper.

## 2. Physical view of the proposed room

Physically, one must have the possibility to move chairs, computers and monitors in the room, as well as energy and logic, in order to compose multiple environments. Figure 2 through Figure 6 show examples of possible configurations, where one can observe the flexibility to move furniture, electrical and logical. It is important to emphasize that the room can be used for meetings with participants present plus remote meetings, i.e., the TVs are used to videoconference in different resolutions (depending on the remote side) and for documents collaboration (all participants – local and remote – can see the same documents in the room TVs).
Figure 2. Multi-purpose room configured for a 24 students classroom (plus $n$ remote students).

Figure 3. Multi-purpose room configured for 24 students group dynamic (local and remote).

Figure 4. Multi-purpose room configured for “U” meeting (local and remote).
3. Technological View of the proposed system

Ideally, the room should allow interoperation of many technologies to comply with a multitude of devices and communication standards, such as the following:

- Telepresence room in high definition (Full HD).
- Ultra-telepresence room in ultra-high definition (UHD 4K).
- Videoconferencing systems (Polycom, Cisco, and others).
- High definition videoconferencing through the personal computer application program.
- Web conferencing (web browser).
- Mobile devices.
- SIP phones.
- Telepresence room in high definition (Full HD).
- Ultra-telepresence room in ultra-high definition (UHD 4K).

The system can span over multiple rooms communicating through audio, video and content collaboration, as well as reaching individual users at home using a web browser or a mobile device.

3.1 System Modules

The multipresence system is totally modular, allowing the inclusion of equipment in an incremental way, and can range from a simple TV, notebook or mobile device, up to the model presented in Figure, which shows a model integrating telepresence, room
videoconference, web conferencing and slide presentation, where the focal point is a surgery in ultra-high definition. Figure shows other model where the focal point is a SAGE2 collaboration environment, with a 4K TV showing some reference images for the meeting or class.

![Figure 7. Configuration with multiple displays.](image_url)

Figure 7. Configuration with multiple displays.

![Figure 8. Configuration with a video wall.](image_url)

Figure 8. Configuration with a video wall.

The innovation promoted by the system is the modularity and ubiquity offered, which is not seen in similar systems. Thus, 4K communications would be interacting with telepresence rooms in full HD, with room systems, stand-alone computers via web conferencing in lower-speed networks and mobile devices. The room is reconfigured quickly and easily depending on the need, optimizing space and allowing better use of resources.

The proposed multi-conference room is currently being deployed in an educational unit of RNP, which is the Brazilian NREN.

4. About SAGE2

SAGE2 (Scalable Amplified Group Environment) is a web-based software tool that enhances collaboration, either for local discussions or adding an extra feature to video conferencing. SAGE2 enable users to share their screen and files over IP networks, creating a virtual board in the cyberspace where remote and local participants in a meeting can share and visualize content (Marrinan, 2014).

The original SAGE software, developed in 2004 by the Electronic Visualization Laboratory of University of Illinois at Chicago (EVL/UIC) was designed to enable groups to work in front of large displays walls in order to solve problems that required juxtaposing large volumes of information in ultra-high-resolution.

Since 2011 RNP is disseminating the usage of SAGE to universities and research laboratories in Brazil. Currently, SAGE2 is adopted by more than one hundred educational and research institutions worldwide. SAGE2 is freely available at [http://www.sagecommons.org](http://www.sagecommons.org).

115 Scalable Amplified Group Environment (www.sagecommons.org)
Conclusion
This paper presented an architectural and technological view of a multiuse room powered by a software developed in Federal University of Rio Grande do Sul and funded mainly by the Brazilian NREN, RNP.

The paper had two main goals: to present the multipresence system trying to disseminate it and spread its use; b) to propose a physical solution for multipurpose rooms using the multipresence system.

One word that defines the multipresence system is “integration”, as it integrates many different technologies, allowing people to participate no matter where they are and what technological platforms they are using. So, people can communicate using mobile phones, tablets, notebooks, computers, symmetrical panels, asymmetrical panels, telepresence rooms, ultra-high definition communication, SIP based systems, and so on. Besides videoconference, the system allows transparent collaboration among these platforms through SAGE2.

Acknowledgements
This work is being funded mainly by RNP (National Education and Research Network), the Brazilian NREN, through the WG (Working Groups) programs. The high definition software of the base system was funded by FINEP (Financing Agency for Studies and Projects).

References

Biographies
Valter Roesler has a Bachelor’s degree in Electrical Engineering (1988), Master’s degree (1993) and PhD degree (2003) in Computer Science. Today he is a professor at the Federal University of Rio Grande do Sul, Brazil. He has experience in Multimedia, Digital TV, Video Encoding, e-Health and Network Monitoring. He coordinates the PRAV laboratory (Projects in Audio and Video) – www.inf.ufrgs.br/prav, with about 30 researchers and projects related to Remote Education and e-Health, in traditional computers and mobile devices. He is the coordinator of the Multipresence project.

Felipe Cecagno has a Bachelor’s degree in Computer Science from the Federal University of Rio Grande do Sul (2010). Since 2008 he works at PRAV Laboratory (Projects in Audio and Video) as researcher and developer on many projects related to Multimedia and Distance Education. He's a technical leader of the Mconf project since its beginning (2010). In early 2013 he co-founded Mconf Tecnologia, a Brazilian company that provides professional services on top of Mconf and related technologies.

Leandro Ciuffo is Manager of Research and Development projects at RNP. Since 2011 he works with user engagement in the scope of the FIBRE Future Internet testbed. He also
coordinates the RNP's R&D Programme on Advanced Applications for Remote Visualization, which includes streaming of ultra-high-definition media. From 2006 to 2009 he worked with Grid Computing and e-Science projects at INFN-Catania (Italy), being responsible for dissemination and user support activities. Leandro holds a M.Sc. in Computer Science from the Federal Fluminense University (UFF) in Brazil.

**Renato Duarte** started working at RNP (National Education and research Network) in 2006 and he has worked as IT Coordinator there since 2013. He works in the educational technology area. He graduated in Computer Science at Unicarioca in 2006. He specialized in IT Project at UFRJ.

**Guilherme Longoni** is the project manager of the Multipresence solution at Federal University of Rio Grande do Sul (UFRGS) in Brazil. From 2011 to 2014 he worked as software developer in MIR project (Multimidia Integrated Room), working with low latency Full-HD surgery transmissions. He is a computer science student at UFRGS.

**Luiz Coelho** is with RNP (National Education and Research Network). He is the director and national coordinator of Superior Network Training Institute (ESR). He has Professional degree in Project Management from IAG/Master of PUC/Rio and Bachelor's degree in Data Processing from Pontifical Catholic University of Rio de Janeiro.
Support to Emerging NRENs

Cathrin STÖVER

*Chief International Relations and Communications Officer, GÉANT*

*City House, Cambridge, United Kingdom*

*Tel: +441223371336, Email: cathrin.stover@geant.org*

**Abstract**

The UbuntuNet Alliance and the AfricaConnect project have led to the creation of various NRENs in Southern and Eastern Africa. Success stories of newly created NRENs can be found, for example, in Zambia or Uganda. But there are still various countries in the region that have not yet created an NREN or an NREN-like organisation and many more where the NREN continues in an embryonic state without the necessary national or international data communications capacity to allow it to operate a production network and offer services to its member institutions. South and Eastern African NRENs are not alone in this situation. Across the world, NRENs struggle to “take the next step” and to keep developing.

**Keywords**

NRENs, RRENs, Value of NRENs, Funding, Support, Publications

**Support Tools Available to Emerging NRENs**

1. **The Case for NREN Portal**

A voluntary group of professionals from regional research and education networking organisations from around the globe has come together over the last year to address the need for support to developing NRENs. Through AfricaConnect co-funding they created a website "The Case for NRENs" making the case to funders and users, showcasing success stories and offering resources and tools for NRENs in development or countries wishing to start the development of an NREN. The portal can be found at [www.casefornrens.org](http://www.casefornrens.org) and offers a pool of resources to emerging NRENs making a pitch to their funding bodies, member institutions and partners. A benchmarking opportunity is given to emerging NRENs to compare against what is deemed a “successful” NREN, allowing for comparison and development towards long term sustainability. The portal makes further resources and tools available to support the development of an NREN organisation such as an example financial model for an NREN.

2. **Research 4 Life**

Research4Life is the collective name for the four programmes – HINARI, AGORA, OARE and ARDI – that provide developing countries with free or low cost access to academic and professional peer-reviewed content online.

Eligible libraries and their users benefit from:

- Online access to up to 45,000 peer-reviewed international scientific journals, books, and databases
• Full-text articles which can be downloaded for saving, printing or reading on screen
• Searching by keyword, subject, author or language
• Resources available in several languages
• Training in information literacy and promotional support

Research4Life is a public-private partnership of the WHO, FAO, UNEP, WIPO, Cornell and Yale Universities and the International Association of Scientific, Technical & Medical Publishers. Working together with technology partner Microsoft, the partnership’s goal is to help attain six of the UN’s eight Millennium Development Goals by 2015, reducing the scientific knowledge gap between industrialized countries and the developing world.

References

www.casefornrens.org
www.research4life.org

Biography

Cathrin Stöver joined GÉANT (then known as DANTE) in October 1997 as External Relations Manager. Between 2002 and 2008 Cathrin was Project Manager of the ALICE project and under her management, ALICE led to the creation of the Latin American RedCLARA network and the CLARA organisation. In 2011, Cathrin was appointed Chief International Relations and Communications Officer and has since steered the company's international networking projects, such as also the AfricaConnect project between 2011 and 2015. Since June 2015, Cathrin project manages the AfricaConnect2 project in the West and Central African region.

Cathrin has a degree in European Business Studies and has studied and worked in Germany, France, the UK and US; she is based in Madrid, Spain.
## PART THREE:
### LIST OF PARTICIPANTS a/z by participant

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