Research and Education Networks, Putting value into the links

Bonny KHUNGA[1], Douglas KUNDA[2],
[1]*Zambia Research and Education Network, Lusaka, Zambia,*
Email: khungab@zamren.zm *or khungab@gmail.com*
[2]*Mulungushi University, Centre for ICTE, Kabwe, Zambia, Email:* dkunda@mu.ac.zm *or douglas.kunda@yahoo.com*

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.

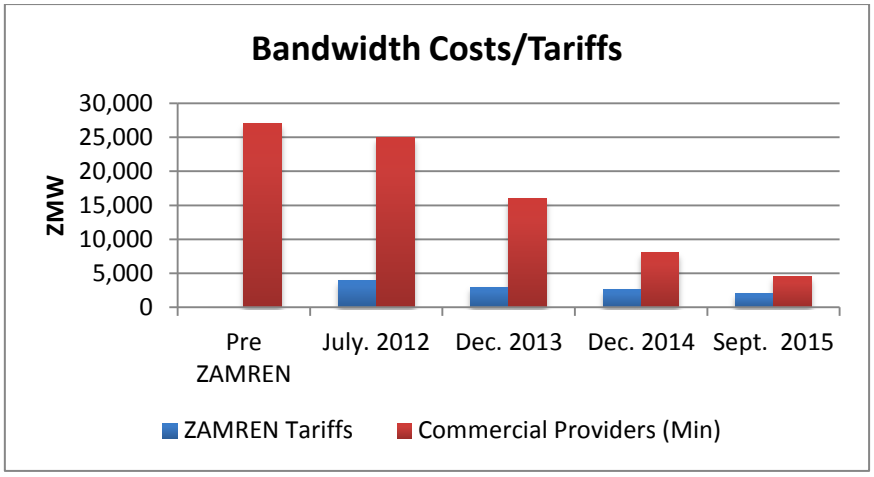
1. Introduction

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.



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

- 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 discontinuingof 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.