COLLABORATION FOR DEVELOPMENT

2018 Newsletter & Annual Report

Research and Education Network for Uganda (RENU)

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Dear Friends,

It gives me great pleasure to introduce this third Annual Newsletter from RENU. 2019 is certainly an important year for the institution and we wish to see to it that during this year our growth and development is steady and measured.

Last year, we did not publish the Newsletter due to various circumstances beyond our control, but we wish to recognise all the great things which were achieved during the year. The membership to RENU has increased to over 60 institutions, with various branches of these institutions also connected to RENU. This brings the total number of connected campuses to over 100. This shows that slowly, RENU is spreading its wings and is covering more and more space in our country, thus broadening the scope of work for RENU.

RENU continues to offer more and more services to member institutions, and I mention but a few; cloud facilities, data center collocation, eduroam, Identity Federation, webhosting, etc. Unfortunately, not sufficient advantage has been taken of these services, and I urge all to seriously consider utilising these facilities to grow your institutions further.

Through these great services offered by RENU, we are creating a community of collaboration which will slowly create close links in the fields of academia and research. And this ultimately is one of the main aims of RENU - how best to see to it that academics and researchers work together. Today work in isolation is no longer possible and we need to pool our efforts together so that we create strong links and offer strong results.

Therefore, the “Academics and Researchers Forum”, which is one of the core activities of RENU, will receive a boost this year and some colleagues have offered to assist in defining as clearly as possible what the Forum wants to achieve and how to achieve it. Ultimately the activities of the Forum will lead to greater development in our country and be the platform where links and collaborations will be worked out and realised. It is my hope that the results of the work of the Forum will benefit all of us members of RENU.

Lastly, I would like to extend a very warm word of gratitude to the outgoing CEO, Engineer Isaac Kasana. For years he has been working hard and in a spirit of generosity to see to the growth of RENU and its academic community. Thank you Isaac for your commitment and dedication to RENU. In 2019 a new CEO will be chosen and we hope that under his/her leadership, RENU will move forward with even longer strides.

Also, a word of thanks to the whole team of RENU, that has worked hand in hand with the CEO and made RENU what it is today.

Let me conclude by wishing you all a pleasant reading of this Newsletter but more importantly to find in it incentives to work always more closely together for our academic and research communities, for it is through collaboration that we will achieve real development. May we all be part of it!

Professor Michel Lejeune
CHAIRMAN BOARD OF DIRECTORS, RENU
MESSAGE FROM THE OUTGOING CEO

Looking Back on 2 Years of Operations (2017 and 2018)

Isaac Kasana

Introduction

First of all, I must start by apologizing for the failure to publish the 2018 edition of the RENU Annual Newsletter. This failure also reflects RENU’s overall challenges during the 2 years that ended in December 2018. During the AGM which took place in April 2018 at the Sheraton Hotel, I apologized for this publication delay and also promised that we would publish it later in the year. So, as I acknowledge failure to publish the 2018 Annual Newsletter, I also express my sincere apology once more.

In comparison to the fast growth of 2015 and 2016, 2017 and 2018 presented a number of growth challenges to RENU which have been characterized by being late on our marks on many fronts, slow execution, uncertainty, resulting in decision delays. Public institutions at some point became unclear about their membership tenure, when a debate arose on how their connectivity needs should be met. Secondly, a number of institutions continued to experience challenges with managing their recurrent connectivity expenses. This brief report is an attempt to think back, give account to RENU’s stakeholders and draw lessons from the way 2017 and 2018 have played out for RENU. Indeed, operationally they seemed like the proverbial (2) lean years following 2 bounty years.

Taking stock of the 2 challenge–years

Even in a lean season, one can find traces of useful lessons and if carefully exploited, shoots of renewal could sprout from a lean season. The storms that have blown against RENU-members’ loyalty in 2017 and 2018 had their origins in 2016 as a reaction to the decisions taken to enhance growth and stronger self-reliance (decisions that received unanimous Board approval).

By the time we headed for UbuntuNet Connect 2017 (UC 2017) which was hosted by the Ethiopian National Research and Education Network (EtherNet) in Addis Ababa in November 2017, two calls to dislodge public institutions from RENU membership had been mooted. One thrust proposed that they be served by the National IT Authority of Uganda (NITA–U) together with their focal mandate for ministries, departments and authorities (MDA). In the second thrust a proposal for public R&E institutions to be served by Uganda Telecom together with other MDAs was mooted. In addition to the above two pushes, a Q3 management decision was made to do more careful year-planning in order to attain more accurate budget performance as a way of moderating the operating surplus attained during the 2016 year. Another pressure source arose out of 2017 being the year when a new head of finance and administration function joined RENU management and needed time to be etched into team-function. The above four factors (a combination of threats and weaknesses) exerted substantial destabilizing pressure on RENU operations during 2017 with an overflow into 2018. Thankfully, each of the two years remained financially positive.
overall in spite of a few extended cash-flow hold ups and for this we wish to acknowledge the patience and flexibility extended to us by our major suppliers such as UbuntuNet Alliance, Liquid Telecom, C Squared Ltd, Soliton Telmec Ltd and SPIDD Africa. Finally, the 2018 annual work plan and budget were late for board approval (March 2018) resulting in RENU’s loss of more than 25% of implementation time for its 2018’s annual plan.

So the first achievement is RENU registering positive financial results for 2017 and 2018, despite the many setbacks faced during this period.

The second major achievement is (thankfully) the retention of all its public member institutions.

The third important achievement is the establishment of a dedicated NOC unit within the technical department, thus putting RENU on a trajectory for enhancing technical support to member institutions.

The fourth significant achievement is the continued entrenchment of systems-based operation and stronger Board oversight over RENU strategic direction and service delivery.

The fifth significant achievement is the commencement of the implementation of risk management measures, starting with addressing banking weaknesses, the insuring of core network infrastructure, addressing policy gaps – including review of the primary governance document (the Memorandum and Articles of Association – MAA), HR policy and guidelines, refining the finance guidelines and strengthening the legal support function.

The sixth significant achievement is the commencement of activities that will feed into a structured monitoring and evaluation (M&E) process in future.

The Seventh achievement was the decision to turn the threat of members’ exodus that started in 2017, into strength by expediting the development of the third 5-year strategic plan, aiming to recover the waning community and cooperative spirit among member institutions.

Lessons

The first lesson drawn from the storms encountered is the realization that enduring lessons can emerge out of adversity and not only from successes and that the strength of a team could best be assessed during adversities.

The need for community engagement was better understood including the need for deeper engagement with the ICT directors’ forum, engagement with the Uganda vice chancellors’ forum (UVCF), identifying processes through which end users’ engagement can happen more effectively and outreach to the Consortium of Uganda University Librarians (CUUL) moved a notch higher. As a bonus to the above, the methodology for engagement became clearer and the need for a more structured communications/PR function became more apparent.

- The need to refine planning, the entrenchment of systems to enhance objectivity, initiation of structured performance management was better recognized as an imperative at this stage of RENU’s growth.

- It is prudent to slow down on growth in order to strengthen structures that will ensure effective controls and stability as RENU operations grow bigger.

Leadership Identification and Nurturing

For any organization, when planning long-term, the sustainability strategy must include both leadership development and leadership transition preparedness, because not to do so would be overlooking an inevitable and mission critical planning issue. Although the planned intervals and the impact will vary with the nature and size of the organization, transition is a universal inevitability. Furthermore, for most man-made physical systems, the ultimate test for stability and resilience is ability to withstand transition and disturbances. Therefore, the external and internal destabilizing effects experienced by RENU brought this consideration to the fore, even though from the start the strategy that was adopted for establishing RENU had leadership development intentionally embedded in most operational activities.

For instance, the RENU Capacity Development Programme and the regular management activities include a strong dose of leadership nurturing using the time-tested 3-band placement of emphasis. In this case, the top-most capacity development emphasis was placed on nurturing a crop of future leaders while the second emphasis was placed on emerging immediate team supervisors (3) and the third significant capacity development emphasis was placed on the rest of the technical support team (9).

Because of the bigger number involved, a bigger budget was assigned to technical
capacity development effort, though budget size does not automatically translate into level of emphasis. It is now entrenched in RENU culture that all persons (including the CEO) are encouraged to pursue continuing capability self-development. However, intense effort and time were expended on mentoring emerging leaders.

The leadership development for RENU as a community-owned and community-driven institution is premised on 4 essential functional pillars namely:

- **Community-building** (establishment, nurturing and engagement; the equivalent of customer centric marketing among commercial enterprises, so as to attain the envisioned community-owned and community-driven national research and education network (NREN).

- **Governance and Leadership** (identification of talent followed by leadership capacity development in order to provide leadership that is characterized by passion, responsibility, integrity, care and excellence (PRICE).

- **Innovation** (This pillar is critical to give the NREN a clear edge by driving technical Excellence).

- **Stewardship** (expressed as prudence in resource mobilization, resource allocation and resource management including emphasis on people, frugal handling of financial resources and ensuring optimal use of technology resources).

**Preparing for and Passing Baton**

The lean years were not only characterized by destabilizing public institutions but the effects were felt (sometimes intensely) by the leadership team. An effort was made to convert the resulting performance degradation into an opportunity to effect an earlier than intended test for leadership transition readiness. The test was actualized when the CEO took a 10-week mini-sabbatical at the beginning of 2017 in order to have focused reflection, analyze and understand the factors giving rise to the many challenges. So, an early extended recess for the CEO also served as an opportunity to test RENU’s leadership transition readiness by allowing the CTO to remain in charge. *(This technique was gleaned from Lee Kuan Yew as described in his book “From Third World to First”; 3rd Edition 2011, pp569).*

Identifying and equipping a more purpose-suited person to strengthen the Finance and administration function was another step in building towards transition readiness. This was done in parallel with ensuring wider membership participation at the 2018 AGM which also ensured a wider catchment for board candidates and elections.

In spite of the extra care taken to ensure a smooth Board renewal, a number of glitches were experienced mostly because many institutions’ executive leaders did not have ample time to become conversant with the requirements of the RENU Memorandum and Articles of Association (MAA).

Still, after some corrective measures, what emerged is a more representative board both in terms of institutional span as well as a more representative representation of end-users (academics and researchers).
Government has two representations on the board, drawn from the Uganda National Council for Science and Technology (UNCST) which is an agency under the new Ministry of Science, Technology and Innovation (MoSTI), and another from RENU’s distinguished partner namely Uganda Communications Commission (UCC) who is also the ICT sector regulator.

The fourth step in building readiness for leadership transition was the 3-staged preparation of the third 5-year strategic plan. This started with induction of the replenished RENU Board and facilitating their high-level input (together with a selection of leaders of leading R&E member intuitions) in providing to the strategic plan development process. The opportunity that the strategic plan development process provided to both operational management and the Board to work closely, helped to identify pending policy and management gaps. At the end of the strategic planning process and the subsequent monitoring and evaluation follow-on activities, areas of weakness were clearly identified for either short term intervention or to be addressed during implementation of the new strategic plan. The other positive outcome of the strategic planning process was the much clearer appreciation of governance and management responsibilities and in a nutshell, it was agreed that the RENU Senior Management Team (SMT) is to focus on Operational Stewardship while the Board is to provide oversight over the SMT.

An extended period of RENU swimming against the currents that sought to weaken its continued development had the uncanny tendency of increasingly having such currents. Having promised the earlier NREN stakeholders that RENU must always come first and having made extensive consultations at both governance and operational level, I felt ready for passing the leadership baton at the end of 2018, after more than five and half years as CEO of RENU. After written communication of this decision to the Chairman of the board, he facilitated a Board meeting to conduct a status review and to ensure that adequate preparation for a smooth transition was done.

The transition process commenced with the chairman’s communication to member institutions and partner institutions, informing them of the end of my tour of duty as RENU CEO. It included visits to some of the founding institutions as illustrated in the pictures below taken during a visit to the Vice Chancellor of Makerere University, where RENU is hosted.

A visit to the Vice Chancellor, Makerere University to bid him farewell and introduce the RENU Management Team
As we advance deeper into 2019, we review 2018, another year of progress in RENU. Below is a summary of the major implementations by the RENU technical team in 2018.

Connectivity and Network Growth

Connected Campuses

29 new campuses were connected in 2018, including campuses in Lira and Jinja. In July 2018, we reached a milestone of 100 campuses connected to the RENU network. We closed 2018 with a total number of 112 campuses connected.

RENU Backbone Upgrades

More sections of the RENU backbone were upgraded to 10 Gbps. The RENU PoP router in Entebbe was upgraded to 10 GE capability.

International and Regional Connectivity

The RENU link from Kampala to London was upgraded from 1 Gbps to 3 Gbps. A new 1 Gbps link from Kampala to Amsterdam was integrated. The RENU interface to the UbuntuNet Alliance network in Kampala was upgraded from 2 Gbps to 10 Gbps.

Uganda Internet eXchange Point (UIXP)

The RENU links to the UIXP were upgraded to 10 Gbps. Direct peering with the Google CDN AS36040 was implemented. Direct peering with 2 international carriers was implemented.

Network Traffic

International and Regional Traffic

Traffic from outside the RENU ASN, that is destined to RENU member institutions now peaks at about 5 Gbps.

Local Traffic

Traffic between RENU member institutions and/or RENU data centers is still very low, i.e. averaging 10 Mbps, and peaking at 100 Mbps. This is evident in Fig. 2.
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On the international side, RENU achieved 100% network availability throughout 2018 – with very few incidents of downgraded service. This was possible because RENU now has 3 independent routes for international connectivity. All the network service downtimes in 2018 were on the local (access) links.

We also integrated a dedicated team that is in charge of the RENU Network Operations Center (NOC). This team has played a big part in improving our management of service outages and incidents.

Network Availability

Throughout 2018, despite the increase in the number of campuses connected to the RENU network, an average of 85% of the connected campuses achieved 100% network availability every given month – up from 75% of the sites in 2017. This trend is shown in Fig. 3. This improvement was achieved through a number of interventions in protecting the backbone and last-mile access links against fibre cuts.

Traffic to NRENs in the UbuntuNet Alliance Region

Traffic between RENU and the NRENs in the region, i.e. KENET, TERNET, ZAMREN and RwEdNet is still very low, averaging less than 2 Mbps.

This is evident in Fig. 2.

Fig. 2: Traffic local to RENU, and traffic between RENU and other NRENs in the region.

Fig. 3: Network service availability in 2018

Advanced NREN Services

The RENU Identity Federation (RIF) and eduGAIN

Despite being established in August 2016, RIF was only able to join eduGAIN in January 2018. In doing so, RIF became the first Identity Federation in Sub-Saharan Africa, outside South Africa, to join eduGAIN. By the end of 2018, RIF had 5 Identity Providers (IDI, RHSP, UCU, RENU Secretariat and ICER Uganda), and 3 Services (FileSender, eduroam, and Mconf web conferencing).

RENU Cloud Services

9 new virtual instances were activated in the RENU Cloud in 2018 for RENU member institutions. By the end of 2018, the total number of instances for RENU member institutions in the RENU Cloud was 13.

Web Hosting

By the end of 2018, 23 websites were being hosted by RENU. 8 of those were 2018 additions.

RENU Data Center Collocation

A total of 5 institutions have their servers hosted in RENU data center. 2 of those were 2018 additions.

eduroam

eduroam is now available at 13 campuses connected to the RENU network. 4 of those campuses were activated in 2018.
RENU CERT

Intrusion Detection Systems (IDS) were integrated in the RENU network. Memoranda of Understanding were signed with more cybersecurity information sources. Vulnerability reports are still available to RENU member institutions, on demand.

Others

perfSONAR

RENU has 2 perfSONAR nodes in the network, i.e. https://pfs-stat-irt.renu.ac.ug/ and https://pfs-mujhu-irt.renu.ac.ug/.

RENU NTP servers

2 NTP servers are still available to RENU member institutions, i.e. ntp-rad.renu.ac.ug and ntp-edu.renu.ac.ug.

Web conferencing

Since 2016, web conferencing is available to RENU member institutions.

Technical Capacity Building

Residential Workshops

In collaboration with the Network Startup Resource Center (NSRC) and the UbuntuNet Alliance, 3 residential workshops were held in 2018. This also saw the introduction of the Federation and Identity Management (FIM) track among RENU workshops. These workshops were attended by a total of 69 participants from RENU member institutions. The workshops were hosted by;

i. Kampala International University – Kansanga Campus, July 2018
   **Theme:** Campus Network Wireless (CNW)

ii. Bugema University – Main Campus, October 2018
   **Theme:** Campus Network Monitoring and Management (CNMM)

iii. Mengo Hospital, April 2018
   **Theme:** Federation and Identity Management (FIM)

Direct Engineering Assistance (DEA)

In collaboration with the Network Startup Resource Center (NSRC), 2 DEAs were carried out in 2018, i.e. at Mengo Hospital and the Bugema University main campus.

Online Workshop

In collaboration with the Internet Society (ISOC), an online workshop was held in February 2018, under the theme “Introduction to Network Operations”. This workshop was attended by 45 participants.

Life After DEA

We introduced the Life After DEA program in 2018. The idea behind this was to review the performance and impact of the DEAs that were carried out in 2014, 2015 and 2016. The rationale was that enough time had elapsed for the effects and impact of the DEAs from those years to be assessed more accurately. A total of 10 campuses were visited for the Life After DEA assessment of 2018, revealing some of the flaws in our approach to DEAs in earlier years. This then guided our approach to DEAs for 2019.
RENU ICT Directors Forum Retreat

In June 2018, we held the first ever RENU ICT Directors Forum Retreat. This was held in Entebbe and was attended by over 50 heads of ICT from RENU member institutions.

This forum is a platform for RENU to provide updates to member institutions on the services available through RENU. It is also a feedback platform for RENU member institutions to channel their expectations and frustrations to the RENU Secretariat.

Coming in 2019

For 2019, the focus is around improving resilience of the local backbone and access links. There will also be attention directed towards upgrading services like the RENU Cloud and the data center facilities. The RENU Computer Emergency Response Team (CERT) will also get busier, with more engagement with member institutions and the UgCERT.

Capacity Building Activities

We have a packed schedule for technical capacity building activities in 2019. Below is a summary of the activities.

3 Residential Workshops

- Federation and Identity Management – FIM (St. Francis Nsambya Hospital – April 2019)
- Scalable Campus Network Design – SCND (KIU Ishaka Campus – October 2019)

2 Direct Engineering Assistance (DEA) exercises (in collaboration with NSRC)

- Lira University, Lira – August 2019
- St. Francis Hospital Nsambya – October 2019

3 Mini Direct Engineering Assistance (DEA) exercises

- Mountains of the Moon University (MMU), Fort Portal – April 2019
- Uganda Virus Research Institute (UVRI), Entebbe – July 2019
- Kabale University, September 2019

Online Workshop (in collaboration with the Internet Society)

- Advanced Network Services – February 2019

Collaboration through Capacity Building

Since 2014, RENU has managed to achieve regional and international collaboration through the RENU Capacity Building Program. Below is a summary of foreign facilitators and participants that have been part of the program. Listed too, are figures of the RENU resources that have supported capacity building activities in the region.

- 13 technical facilitators from Tanzania, Zambia, Kenya, South Africa, Malawi and the US.
- 7 technical facilitators from NSRC, i.e. USA, UK, Gambia, Ghana, Tanzania.
- 4 RENU technical facilitators have been sent to Zambia, Tanzania and South Africa.
- 7 RENU participants have attended the UbuntuNet Alliance regional capacity building workshops in Mozambique, Zambia, Ethiopia and Zanzibar.
- 2 participants from Ethiopia attended a RENU workshop and DEA in 2017.
THE SPIRIT OF COOPERATION

Building the Global Research and Education Network Fabric

By Steven Huter and Hervey Allen

Steve Huter is the Director for the Network Startup Resource Center (NSRC) and a Research Associate at the University of Oregon. Steve has worked with thousands of network engineers, scientists, and Internet technology developers in more than one hundred countries around the world to help build Internet infrastructure and establish international partnerships in support of research and education. Building on the relationships established over the years, he helps cultivate a community of technical professionals on a global scale to train indigenous network engineers who enable continuous progress for expanding the Internet into new areas, with a focus on affordable access.

Millions of people around the world have benefited from the creation and global growth of the Internet over the past few decades. The internet provides tools and systems to address some of our biggest global challenges, including the delivery of affordable education and healthcare, sourcing clean water, increasing energy efficiency, and helping governments become more effective and responsive to the needs of their citizens.

But we've only scratched the surface on the potential of the Internet and its many applications. The global research and education community, through its tremendous international cooperation, leads much of the valuable work that has been achieved to enhance the impacts of the Internet's educational resources and scientific advancements.

In order to maintain this momentum for research enterprises to flourish at emerging international sites there must be enabling network infrastructure, well-trained local support, ready access to new technologies, and ongoing educational opportunities for local engineers and technologists. Improved infrastructure and increased bandwidth enable international researchers to document
and publish more local, indigenous data and publish more co-authored papers with their colleagues anywhere in the world. The improved communications resulting from these efforts enhance collaboration between scientists and engineers across the entire connectivity spectrum; this ultimately helps attract a wider variety of ideas, information, talent, and resources to solving problems.

The Internet is the greatest engineering feat in the history of the world, and it’s ultimately so much more than just fiber links and routers and servers and datacenters. The heart of the Internet is made of people reaching out to each other to connect and communicate for a myriad of reasons. To further expand this amazing global network of networks to more people in areas of the world that are interested in connecting to the Internet, and do not yet have affordable mechanisms, we’d like to emphasize the importance of the people required to do this effectively and sustainably.

The organization we work for is called the Network Startup Resource Center (NSRC), which was formally established about 27 years ago with a grant from the U.S. National Science Foundation and the initial objective of helping scientists in the USA connect with other scientists around the world through the Internet. The scope of activities and communities of interest we support grew over the years as the Internet expanded, but we still place major emphasis on the education sector, and the importance of incubating and interconnecting research and education networks all over the world.

Mirroring experience elsewhere in the world, enabling academic access to the Internet eventually produces graduates familiar with the Internet and its applications, who are then equipped to enter into the private sector, academia, or e-government agencies to offer Internet services to the public in their countries and cultures. As a positive trend, we are observing many of the well-connected universities and R&E networks connecting secondary schools and public libraries in their countries when they can, which further extends the penetration of Internet access at minimal additional cost. Real-time access to educational resources is vital for youth who seek to lead social, economic and scientific developments in their countries.

To perpetually advance these goals, the NSRC specializes in promoting a culture of network operators that help each other, thereby cultivating a community of professionals to enable continuous progress.

The NSRC provides an international leadership role for the global scientific community by helping to incubate and build national and regional research and education networks (NRENs and RRENs) through targeted capacity building activities and collaborative partnerships with universities, network service providers, industry and government agencies in Africa, Asia-Pacific, Europe, the Middle East, North America, Latin America and the Caribbean. NSRC is based at the University of Oregon with partnerships across the global Internet industry, governmental agencies, network service providers and R&E networks around the world.

Through hands-on, lab-based curricula and a train-the-trainers approach, NSRC provides technical capacity development to many thousands of network engineers working in hundreds of R&E institutions to augment networking expertise around the world.

**NSRC Model for Building Network Infrastructure and Human Resources**

- Combines technical training and human resource development activities
- Direct engineering assistance (DEA) to improve operational infrastructure
- Participatory development of a request-driven approach is critical to successful outcomes

**Why Focus on Campus Networks?**

- The physical network is the transport layer. Without it, nothing else is possible.
- The campus network is the foundation for research and education activities.
- To optimally utilize network capacity, equipment and personnel, it’s essential to design and build well-structured university networks, with all of the campus segments and academic departments included.
- There is a clear need to scale rapidly so the current phase of investments succeeds.
Improved connectivity is necessary, but not sufficient for the optimal operation of an NREN and its connection to the regional REN. Many institutions need improvements to their core network infrastructure to be able to take advantage of higher speed network connections, such as those provided via the UbuntuNet Alliance or the West and Central African Research and Education Network (WACREN).

When a higher bandwidth connection becomes available, if the networks have been designed around using minimal connection speeds, then they need to be redesigned or updated to avoid causing bottlenecks that make it difficult to take advantage of newer, high-speed connections. NSRC works to build human capacity and expertise in the areas of network routing, campus network design, network monitoring and management, virtualization and hybrid cloud systems, and network security so that institutions can properly design, implement and run high-speed networks on their own, with their network personnel leading the operations and growth of the networks.

In addition to technical training, NSRC personnel work shoulder-to-shoulder with an institution’s network engineers to provide direct engineering assistance to make recommended changes, install and configure newly donated network hardware (sometimes supplied by the NSRC), and to verify that local network personnel can do all of the operations and maintenance on their own.

The NSRC’s model and techniques rely on what we like to describe as the spirit of cooperation. When NSRC facilitates technical capacity building in a country or region with local partner organizations, we are always looking out for talented local people who are interested in giving back to their communities. NSRC leverages our impact by training new trainers and providing the tools necessary so that local network engineers can continue to build their local network infrastructure to serve their communities.

• No scientist is connected directly to a national R&E network. They are all connected to campus or enterprise networks for access.

Steve Huter of NSRC and Isaac Kasana of RENU

‘The NSRC’s model and techniques rely on what we like to describe as the spirit of cooperation.’
Key elements of this Internet development model include:

- Local hands, cultivating local expertise – network engineers are among the most critical human resources for all countries of the world in the 21st century
- Well-trained network engineers create the necessary critical mass of skills in all countries to interoperate with the many thousands of networks around the world that form the Internet
- This leads to the creation of much-needed jobs, employment, and new opportunities for innovation for people anywhere in the world
- This is particularly important for cultivating viable business models in rural areas
- Every country needs as much investment in its people as infrastructure to ensure a future of affordable access for all
- First and foremost, this means capable network engineers, system administrators, and information technology support personnel, but also informed policy makers who can clear obstacles and create good policies that allow for open architecture networking and shared infrastructure, such as neutral Internet Exchange Points
- Open architecture networking and open access network policies are what makes the internet the internet
- Local leadership is vital for this to work and for the networks to be sustainable
- The creation of culturally appropriate and educationally useful content in more countries and cultures around the world is also of great importance for enriching the global Internet and increasing its utility value for all
- The combination of improving infrastructure, which creates more supply, and people working together to deliver relevant platforms and services, which drives demand, is good for the whole Internet ecosystem

**Key lessons that we have learned**

- Listen first: In order to ensure that we are actually addressing and solving the right problems, we need to listen first - What do the local people in a community request? What do they desire from the Internet and its potential resources?
- Participatory development works best when people on the ground, the techies and entrepreneurs, are working hand-in-hand with government agencies and other high-level bodies concurrently. Cooperation with government agencies, ministerial level policy makers and other key stakeholders to invest in their respective networks and create helpful policies to enable internet development, while working directly with hands-on network engineers who build and maintain the physical networks will result in local hands cultivating local expertise, thereby increasing the likelihood of sustainable internet infrastructure than can provide the desired social and economic transformation in a country or region. The interplay between technology decisions and policy leadership is very important.
- Regional cooperation and enhancing South-South collaboration can often reduce costs, aggregate demand and improve access for larger numbers of people, resulting in greater constructive impacts over time.
- Respect your peers: And we mean this in both the network sense of peering with other physical networks to efficiently exchange content, and in the human sense, of respecting and cultivating a community of peers to build and improve a global internet that benefits all parties.
Collaboration for Development
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15,750 total people trained 2010–2018
12,350 cumulative men trained
3,400 cumulative women trained

Activities aggregated by city. Countries with >10 total activities labeled.
1990-2018 activity data from NSRC; basemap imagery from Natural Earth.
Cartography by University of Oregon InfoGraphics Lab, Department of Geography.
Printed February 26th, 2019.

NSRC Global Internet Development Activities

People Trained Globally Each Year

15,750 total people trained 2010–2018
12,350 cumulative men trained
3,400 cumulative women trained
To help women have a stronger hand in protecting themselves discreetly from HIV during sexual intercourse, the US National Institutes of Health through the HIV Prevention Networks (HPTN) granted funds to seven countries in Southern and Eastern Africa to enroll up to 3,200 volunteering women aged 18 to 45 years. Makerere University–Johns Hopkins University Research Collaboration (MUJHU), Baylor–Uganda, and the Uganda Virus Research Institute (UVRI) are the Uganda sites that were selected for this landmark trial. Critical to the trial, is the safety of the volunteering women. The trial was aimed at finding out if administration of a long-lasting injectable pre-exposure prophylaxis (PrEP) drug called cabotegravir (CAB) would work better than swallowing daily, a combination of two HIV drugs; Tenofovir disoproxil fumarate 300mg plus Emtricitabine 200 mg (TDF/FTC) among HIV negative sexually active women.

MUJHU, Baylor–Uganda and UVRI–IAVI were among other various clinical research and care institutions that subscribe to RENU membership. The three institutions were tasked by the sponsors to ensure that if a woman is recruited by one institution, she would not be recruited by any of the rest of the institutions. Incredibly, the sites have been able to successfully satisfy this critical sponsor requirement by exploiting the collaborative structure of RENU!!
At the end of 2017 the three sites were asked to show how they would ensure that when they went out to recruit participating women, they would not end up recruiting the same women to their individual sites. The permission to start the trial was heavily hinged on this critical requirement and as such, the scientists at these sites were desperate for a solution. With the idea to utilize some form of biometrics, they turned to their IT Managers for a solution.

When the IT Managers met, several ideas were proposed based on previous experiences that included:

1. A previously tried system by the International Aids Vaccine Initiative (IAVI) that used netbooks and 3G connections to transmit fingerprints to a Microsoft cloud database for comparison. Lessons gathered from this experience showed that access to the cloud was extremely slow and frustrating.

2. Using mobile phone fingerprint authentication mechanisms. This was dropped due to the complex nature of the Android system not being able to store fingerprint data outside the device of enrollment.

3. Utilizing an attendance system that is already in use at the three sites. This idea would be a cheaper and easier to achieve feat but the challenge was that each of the sites had a unique vendor for their attendance system.

All IT Managers therefore agreed to explore the third option. Unlike the other sites, Baylor-Uganda was using a locally sourced vendor but was running the fingerprint database within the network. To be able to work out a co-enrollment solution, all sites had to enroll fingerprints to a centralized database that would synchronize in real-time the enrollment devices. The enrollment devices needed to query the database to see if the fingerprint already existed, and thus would facilitate the clinicians to know that the volunteering trial participant is already part of the trial.

With clarity of core need among the three sites, all agreed that either access to the database would have to be shared with the other sites or a database had to be put at a network location, central to all the three sites. Given the computing constraints that this would add to the site in terms of bandwidth and security, a unanimous agreement was reached that the database be hosted on a cloud location. The ideas that were floated for the cloud solution included using Amazon AWS, Microsoft Azure or Oracle cloud and the RENU Cloud.

When the factors at play were weighed, i.e. costs, location of these cloud services and the legal implications of storing biometric data, it was obvious that the RENU Cloud would offer a much better alternative. Costs for using the RENU cloud were less than a quarter of the comparative pricing for the other candidates.

When the solution was presented to RENU, which is also demonstrated below to the scientists, they were excited and welcoming to this arrangement. The solution was then shared with the funders who agreed that it would meet the conditional criteria satisfactorily and based on this the sites were given a green light to go ahead and finalize all preparations to start the trial.
Negotiations with the RENU secretariat were started on a pricing/billing model for this service. Given that for the logistics team at RENU it was a single unit product to be shared among three separate entities, there was a conundrum on who would engage on the service level agreement and who would be billed. However, since all sites were inherently in the same collaborative relationship through RENU, it was agreed that each would take turns to meet the costs every calendar year. This was a triumph that would never have been achieved with a commercial vendor service level agreement.

On the 1st of August 2018, using two biometric devices, each connected to the internet via a GSM data provider, testing was done with fingerprints of the HPTN 084 leadership at MUJHU including Dr. Clemensia Nakabiito the Principle Investigator, Dr. Brenda Gati the Co-Investigator, Dr. Sheila Kabahenda the Study Coordinator, Dr. Paul Natureeba the associate study coordinator and Dr. Simon Africa. All fingerprints were enrolled on one device which was then turned off after 1 minute. The second device was turned on and given a waiting time of a minute after confirming connectivity was up. When the whole team placed their fingerprints on the second device, it confirmed them as existing in its local database. As Dr. Clemencia Nakabiito noted, this was a successful demonstration that we had been able to implement a field usable co-enrollment avoidance solution for a clinical research environment.

I will conclude by quoting Zachary Tumin in his book *Collaborate or Perish!: Reaching Across Boundaries in a Networked World*; “Being connected is important – but it’s no silver bullet. Technology can tip change, and speed it up but if it were only about technology, the one with the best toys would always win.”

We should continue to strive to utilize the value of our NREN, RENU beyond the “Being connected state” so that the affordable and fast connectivity it offers develops utilities that represent the IT Department as a value addition to our institutions’ mission, vision and objectives.
Forging Meaningful Synergies between NRENs and CSPs

The Case of Uganda’s NREN (RENU)

By Isaac Kasana & Nicholas Mbonimpa

Isaac Kasana was CEO of RENU from 2013 to 2018. Before, he was Director of University ICT Services at Uganda Christian University (UCU). He also worked as an Electronics & ICT Consultant. Before that, he was General Manager of AFSAT Communications (U) Ltd for three years, during which he oversaw the introduction of Ku-band VSAT terminals for Internet and data communications applications in Uganda. He is a corporate member of UIPE (MUIPE), is registered as an Engineer by the Engineers Registration Board of Uganda (R.Eng), and is a member of the Institute of Electrical and Electronic Engineers (MIEEE). He is a member of the board of Trustees of the UbuntuNet Alliance.

Nicholas Mbonimpa is the Chief Technical Officer (CTO) of RENU, a position he has held since 2014. He has over 10 years of experience in data network planning and design. He previously worked as a Data Network Planning Engineer for MTN Uganda, and as a Satellite Systems Engineer for iWayAfrica (U) Limited.
Abstract

In the first five years of its existence, when RENU was not able to operate its own network, an effort was made to establish a symbiotic relationship with a then leading Commercial Service Provider (CSP). A consortium of willing Ugandan research and education (R&E) institutions engaged this CSP under the auspices of RENU in a first attempt at collective bargaining to get the maximum possible discount on bandwidth unit price. The Uganda R&E institutions' bandwidth purchase consortium that emerged was in operation for about four years before ending acrimoniously in December 2013. This was after RENU succeeded to complete the process specified by UbuntuNet Alliance for its member NRENs becoming eligible for admission to the EU-supported AfricaConnect project in September 2013, thus becoming eligible to benefit from AfricaConnect.

RENU's receipt of a Private Network Operator's (PNO) license from the national regulator combined with its eligibility for AfricaConnect, created a unique opportunity for Uganda's R&E institutions to initiate their cooperatively-owned private network. This network would be dedicated to serving the institutions' connectivity, access and collaboration needs, to empower their communities of practice, and thus trigger the development of a more effective National Research and Education Network (NREN) in Uganda.

This article is based on a paper that presents RENU's experience on this journey from inception, through various growth stages, between 2013 and 2017. It focuses on the meaningful synergies that have emerged between the NREN and a still growing number of CSPs by intentionally cultivating mutually beneficial business opportunities. The pursuit of competitiveness, the methodology for enhancing this competitiveness and the resulting impact are also reported and illustrated from a community-driven perspective for Uganda's R&E institutions, both public and private. The article assesses the failure of the NREN's initial attempt to develop a symbiotic working relationship with a CSP; explains the process of adopting a model for shared infrastructure access; and highlights the exploitation of a zoned public/private partnership environment supplemented by international connectivity, provided through development partner assistance, as a combination that triggered a more viable academia/industry partnership regime.

The article also outlines the experience of initiating a dedicated R&E network that was (pre-determined) to operate as a community-owned and community-driven network, and highlights the effect of the providential rapid-growth phase that resulted into viability and maturity faster than would have ordinarily been possible. The goals and objectives that guided the new approach for nurturing the NREN initiative, the business and ownership models adopted are presented and explained along with opportunities that were explored. Additionally, the article presents what worked and what did not work, the challenges experienced and how they were mitigated.

Finally, this article shares RENU's experience in its effort to mainstream the use of meaningful synergies with CSPs and documents the lessons learnt so far. It provides performance evaluation over the first 30 months of stand-alone network operation through a tabular Outcome to Purpose Review (OPR) report plus the trending of unit price and aggregate bandwidth over the same period.

Keywords/phrases: Community-owned, Community-driven; Competitiveness; Synergy, aggregate-bandwidth unit price trending, long-term sustainability. Commercial service provider (CSPs)

In January 2006, a group of seven Vice Chancellors of both public and private universities and two heads of research institutions met in Entebbe on the shores of Lake Victoria and made a binding resolution to authorise the establishment of a national research and education network in Uganda. They assigned the task of operationalizing their resolution to an interim task team of five persons. In the first five years of its existence after incorporation (as a not-for-profit company limited by guarantee) in 2008, the Research and Education Network for Uganda (RENU) had not been able to establish and operate its own network. However, effort had been made to establish a symbiotic relationship with a then leading commercial service provider (CSP) with whom a consortium of willing R&E institutions negotiated under the auspices of the RENU secretariat for the maximum possible discount on bandwidth unit price.

The Uganda R&E institutions' bandwidth purchase consortium (BPC) that emerged was in operation for about four years before ending acrimoniously in December 2013. By this time, RENU had succeeded in fulfilling the requirements for joining the EU-supported AfricaConnect project in September 2013, that was jointly managed by UbuntuNet Alliance and GEANT (the European regional research and education Network).

Prior to its admission to the AfricaConnect project, in a period that spanned about 2 years, RENU had succeeded in getting endorsement as Uganda's NREN by both the Ministry of Education and Sports and the telecommunications regulator, Uganda Communications Commission (UCC) who also granted it a PNO license. These endorsements combined with its eligibility for AfricaConnect from September 2013 all lined up to create a unique opportunity for Uganda's R&E institutions to initiate their own cooperatively-owned private network. The network was to be dedicated to serving the member R&E Institutions' needs of connectivity, access to research and education online resources, and collaboration-facilitation in order to better empower their communities of practice. This cocktail of events triggered the commencement and development of a more effective National Research and Education network (NREN) in Uganda, RENU.

Laying a Foundation – From BPC to PNO

The Bandwidth Purchase Consortium (BPC) comprised about 10 institutions (including a number of leading public universities, a few leading private universities and a few leading research institutions). However, the vast majority of private universities and major research organisations had their own private arrangement for Internet access. A number of private universities were connecting through the same CSP that the consortium was working with but through their own privately negotiated arrangements.

The BPC was wreaked with challenges such as the very low internally generated revenue that RENU was able to extract from a small administration fee it levied on the monthly bandwidth. Low revenue generation was also because of the fact that the aggregate bandwidth handled was still very low due to the still very high unit price (at $630 per Mbps per month in 2013) that the CSP exacted from the institutions, even after the group discount it had allowed. The other challenges included failure of timely revenue collection, income tax levied on the still small revenue streams, and the difficulty of attracting more institutions to consortium membership since there was no compelling incentive for them to join the consortium because the price differential was either non-existent or negligible at best. To compound the problem, the partner CSP had very poor Quality of Service (QoS) performance at the time so the BPC opportunity died a-not-so-slow death.

Therefore, when the AfricaConnect Point of Presence (PoP) arrived in Kampala, it presented a new opportunity and it was imperative that RENU would grab it and make the most of it. However, there were still some missing pieces of the puzzle and key among them was finding a means of providing last-mile connection between the institutions and the envisaged RENU PoP, at a cost that most institutions could afford. Several options for last-mile connection were explored between October 2013 and February 2014, and they were all futile (for varying reasons) until it was decided that RENU engages a recently established Public Infrastructure Provider (PIP) company trading as "CSquared Limited", which had been established by Google's exploratory "Project Link" program.

Therefore, when the AfricaConnect Point of Presence (PoP) arrived in Kampala, it presented a new opportunity and it was imperative that RENU would grab it and make the most of it.
The feasibility of using shared fibre infrastructure, especially last-mile fibre was then explored. When an agreement was finally concluded between RENU and CSquared, the building of the dedicated research and education network was able to commence.

It was decided from the start that the NREN would be based on a community-driven and community-owned model (akin to what had been extensively employed for providing access to under-served communities through pro-poor communications initiatives)\(^1\). Secondly, it was also pre-decided to follow a true cost recovery not-for-profit business model. This is an operations methodology in which all expenses incurred in the provision of service to member institutions are taken into account when costing the cocktail of NREN services. This model even captures the monthly amortisation rate, so that provision for network equipment replenishment can be adequately prepared for.

At the end of February 2014, the first campus was connected to the newly established RENU PoP. This was followed by the addition of three other campuses by the end of March 2014, including the main campus of the largest university in Uganda. By July 2014, at least 5 sites had been connected within the Kampala metropolitan area where CSquared fibre cable had its footprint, but two of them had persistent technical problems. Despite these steps, many institutions had arguably the most transformational impact on RENU’s growth and development. The negotiation lasted more than 6 months all together, but when it was agreed, it had arguably the most transformational impact on RENU’s growth and development.

The Greater Kampala Metropolitan Area (GKMA) connectivity agreement with Project Link’s CSquared Limited took quite long to conclude. The negotiation lasted more than 6 months all together, but when it was agreed, it had arguably the most transformational impact on RENU’s growth and development.

The agreement that was eventually concluded provided for a fixed price per site connected irrespective of distance between the site and RENU’s Kampala PoPs. The capacity agreed was for dark fibre meaning that the link throughput depended on specifications of the RENU backbone equipment, and the member institution network border equipment that were to light the dark fibre. The dark fibre offer meant that RENU was sure of almost unlimited scaling of last-mile link bandwidth for the GKMA. Initially the maximum bandwidth was set at 1 Gbps through the choice of Small Factor Pluggable (SFP) modules used. In the GMKA area most sites could be served using 10 km range SFPs, and the longest range SFPs needed were those of 80km distance range. These core service level parameters were used to determine that the least break-even international link capacity for connected RENU member institutions should be 10 Mbps. It was also determined that the higher the international bandwidth an institution subscribed for, the lower the unit price contribution by the last-mile segment. For example, for a college subscribing for 100 Mbps (since the last-mile contribution to unit price would be the ratio of the fixed and uniform monthly charge per link to the bandwidth subscribed) RENU incurred a cost as low as $3 per Mbps per month.

It was eventually decided that institutions with monthly budgets only able to cover 5 Mbps, though not financially viable, would be connected on the understanding that those with high international bandwidth would offset the loss. The benefit envisaged in allowing sub-optimal connections of 5 Mbps was that more institutions would be open to local collaboration including the sharing of resources over very fast local fibre links. This strategy had a net effect of speeding up membership growth and eventually sped up growth of aggregate bandwidth.

Another way that the GKMA was maximised was through focusing the membership drive on institutions in the GKMA where the Non-Recurrent Costs (NRC) were now not only uniform but substantially lower than what was offered in other parts of the country at the time. It also resulted in other infrastructure providers improving terms for providing RENU last-mile and back haul links on their infrastructure. It is noted that when local traffic finally exceeded the initial 1Gbps limit (somewhere in 2017), it was much more economical to effect upgrade of the backbone (to say 10 Gbps) by simply changing SFPs from 1 Gbps to 10 Gbps since RENU backbone equipment was by 2017 capable of multiple 10 Gbps channels.

It was also because of the dark fibre links from Google’s Project Link that RENU was able to deliver on the promise of uncapped data transmission rates between networks of member institutions connected to the RENU network. This is an enabler and the building block of digital collaboration between RENU member institutions.

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\(^1\): Uganda Country-based Research, Policy Support and Advocacy Partnerships for Pro-Poor ICT © January 2006 UNDP/WOUGNET.

\(^2\): An extended sharing model to provide ICT services to the rural poor by D.Dang, B.Sultana and K.Umemoto© JAIST 2008.

\(^3\): Community-based Networks and Innovative Technologies: New models to serve the poor. By Sean O’Siochru and Bruce Girard © UNDP 2005.
Connecting the Upcountry Campuses

Despite its great contribution towards the take-off of the RENU network, Google’s Project Link implementation remained within the confines of the GKMA region, within a radius of about 40 km around Kampala, to include the towns of Mukono and Entebbe. This meant that RENU had to find alternative solutions to connect member institutions that are located further outside the capital city.

The second service provider to work with RENU was the National Information Technology Authority – Uganda (NITA-U). Unlike CSquared Limited (Google), and the other service providers, NITA-U is a government parastatal, established to coordinate and regulate information technology services in Uganda. NITA-U owns a couple of data centres and transmission sites countrywide, plus the national fibre backbone. RENU signed a Memorandum of Understanding (MoU) with NITA-U in April 2014. This MoU was to govern how NITA-U would work with RENU, especially with regards to how RENU would utilise the national fibre backbone (owned by NITA-U) and the various data centres at subsidised rates. The first realisation of the benefits from this MoU was the hosting of the first ever RENU PoP in a NITA-U data centre in Kampala, at very subsidised rates that could not be offered by the commercial service providers. NITA-U now provides RENU links connecting the RENU backbone to the East and North of the country. RENU backbone routing and switching equipment outside Kampala is also hosted in NITA-U facilities.

In the second half of 2014, Bandwidth and Cloud Services (BCS) became the second commercial fibre infrastructure provider (after CSquared Limited) to work with RENU. From BCS, RENU procured a leased capacity circuit to deliver fibre to the west of the country. RENU set up a Point of Presence (PoP) in Mbarara in September 2014. The capacity procured from BCS would form the first unprotected backbone link from Kampala to Mbarara. BCS also implemented the first last-mile links to connect institutions in Mbarara and further southwest in Kabale. After establishing a PoP in Mbarara, many institutions in that region approached RENU to address their connectivity needs. However, an affordable last-mile fibre provider in that region remained elusive. Liquid-Infocom provided the solution to this problem.

On 1st August 2015, Liquid-Infocom became the third commercial provider to work with RENU. Liquid-Infocom adopted a shared dark fibre model to address the issue of unaffordable last-mile access fibre links connecting RENU’s various member institutions in Mbarara. This model was cost effective, and quickly increased the number of campuses in Western Uganda connected to the RENU network from 1 to 6. They were not just connected, but each of the campuses also had a backup dark fibre link for protection against fibre cuts. After commissioning the RENU sub-ring model in Mbarara, Liquid-Infocom was then later approached to provide an alternative RENU backbone circuit from Kampala to Mbarara. This greatly improved service uptime and availability for RENU connectivity to Western Uganda. Liquid-Infocom now also provides, since September 2016, a point to point link between RENU and the UbuntuNet Alliance PoP in London.

Whereas NITA-U provided the links that connected the RENU PoPs in Gulu (North) and Mbale (East) back to Kampala, affordable last mile fibre solutions were still hard to come by in those regions.

In July 2015, FARO Technical Services (FTS) became the fourth commercial service provider to work with RENU. FTS was contracted by RENU to implement a RENU owned dark fibre sub-ring network in the metropolis of Mbale in Eastern Uganda. This was implemented at reasonably subsidised rates (about $3,000 per km). This cost was subdivided among the different campuses in that town, and each campus was able to get fibre connectivity at rates that were not possible before. RENU’s choice of the little-known FTS over the established players was after the realisation that rates from the commercial service providers in that region were not, in 2015, about to be affordable for RENU operations at the time and in the near future. Important to note too is that unlike all the other previous installations, the fibre infrastructure implemented by FTS in Mbale, is owned entirely by RENU.

In January 2017, MTN Uganda and American Tower Company Uganda joined the list of commercial service providers working with RENU. MTN Uganda is providing backhaul capacity from Arua (in the West Nile region) to the RENU PoP in Gulu, and ATC Uganda is hosting the RENU aggregation site in West Nile. In January 2017, Airtel Uganda joined the list of CSPs working with RENU when RENU procured rack space in the data center at Airtel House in Kampala.

The RENU model of subcontracting various service providers has enabled RENU procure in-country bandwidth for as low as $0.3- $7.5 per Mbps per Month. It has created an atmosphere where the different service providers are
competing to offer the best possible rates and service quality to RENU. This has helped RENU build a solid and burstable local network at affordable rates. This model has also helped RENU maintain a thin team while delivering world-class connectivity services. This has greatly helped keep the RENU operating expenses as low as possible.

The Effects of the Rapid Growth Phase

The steep bandwidth price reduction and the confidence building for network engineers (generated by the RENU technical capacity building program) combined to generate a growth pace faster than had been anticipated. Even in light of the fact that research and education connectivity is influenced by factors beyond institutions’ control, RENU’s membership growth was a pleasant encouragement.

The effects of that rapid growth included the following:

i. A number of institutions still struggled with meeting their bandwidth budgets which resulted in accumulation of accounts receivable.

ii. After campus networks registered performance improvement, the systems and content utilization capability of institutions continued to lag behind.

iii. Institutions in hard to reach upcountry locations expressed interest to be added to the network but this need could not be readily met, which temporarily exacerbated the urban-rural connectivity divide.

iv. The need to upgrade the network backbone equipment came sooner than had been anticipated and generated budgetary pressure that somewhat stretched the cash flow.

v. The private sector responded to RENU’s not-for-profit pricing with faster than normal price drops and in some cases forming alliances to become more competitive. The arrival to Kampala of intercontinental Public Infrastructure Providers (PIP) also increased and resulted in steep change of volume-purchase pricing structure in the market. This put pressure on RENU to be more intentional about finding a way around the pricing asymptote it experienced after the second year of own-network operation.

Enhancing NREN Competitiveness

RENU’s response to the last effect in the section above was to be more intentional in identifying sources of inefficiency, and coming up with a strategy to improve its competitiveness. The first step taken was to develop a network topology that would ensure all round resilience at all stages of the network, including the interface between the RENU network and the campus networks. Delivering a primary and secondary fibre at each campus was adopted as the standard for access links. The primary fibre link connected to one RENU PoP and the secondary connected to a different RENU PoP.

Internationally and regionally, it was resolved that RENU would seek to peer with the UbuntuNet Alliance at two points. The first peering point was at the premier PoP, at a location where RENU was collocating with UbuntuNet Alliance at the UbuntuNet Alliance’s only in-country international gateway in Kampala. The second peering point was resolved to be done in Europe, after exhausting alternatives that the UbuntuNet Alliance could provide in-country. RENU was already aware that even UbuntuNet Alliance had two peering points with the GEANT network.

These were supplemented by reconstitution of the RENU Network Operations Center (NOC) and the associated monitoring team, as well as enhancement of the NOC communication with member institutions. The above measures were sure to greatly enhance the network’s
all-round resilience as has been verified by performance measurements that have been subsequently conducted regularly by the RENU technical team.

The second intervention was to explore international PIP unit price ranges and this was done by undertaking a competitive bid process involving 5 international PIP operators. Through this process, it was discovered that several international PIP providers could offer unit prices that were several times lower than the price that RENU was paying at the time.

The discussions that followed the above interventions resulted substantially in improved quality of service and availability, and the creation of a much more competitive NREN bandwidth pricing scheme that suited the operational needs of both small and large institutions, while at the same time it secured room for future pricing improvements.

Figure 1 shows the high-level network topologies of the RENU backbone before and after implementation of international redundancy, and Figure 2 shows the progression of service availability for campuses connected to the RENU network for selected months in the growth period between 2015 and 2017. It is important to note that since the commissioning of the second entry point into the UbuntuNet Alliance network – London (international redundancy) in September 2016, total network outages are an issue of the past for the RENU community.

Assessing the Overall Impact of the NREN Debut

Assessing overall Impact by two methods namely:

i. An Outcome to Purpose Review (OPR) report presented in tabular form derived from a modified Key Results Areas (KRA) matrix in Table 1, with the 7-fold purpose presented as the heading. The OPR covers a period of 32 months starting March 2014, when a dedicated RENU network was commissioned.

ii. A graph portraying the trending of both the aggregate international bandwidth and the average associated unit price in Figure 3.

7-Fold Purpose: Provides a resilient high-speed connectivity to link most R&E institutions in Uganda (public & private) to facilitate local collaboration having quality access to the global R&E network and to the Internet augmented by services, and applications that support research collaboration. It also provides technical capacity building to attain NREN sustainability.
<table>
<thead>
<tr>
<th>No.</th>
<th>Key Results Areas (KRA)</th>
<th>Key Performance Indicators (KPI)</th>
<th>36 Months Outcome</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NREN Coverage + Expansion + Grow membership</td>
<td>Percentage of country reached by R&amp;E network &amp; No of connected Sites.</td>
<td>[75%] 3 upcountry PoPs &amp; 3 aggregation points + 3 GKMA PoPs + 2 aggregation points; &gt;65 sites of which 15 are upcountry.</td>
<td>Funded by internal revenue streams 2 new towns to be added in 2017.</td>
</tr>
<tr>
<td>2</td>
<td>Facilitate Local R&amp;E Collaboration.</td>
<td>Traffic exchange between local sites</td>
<td>RENU does not bill for local traffic.</td>
<td>In GKMA, network supports up to 1Gbps &amp; upcountry it varies between 70Mbps and 400 Mbps</td>
</tr>
<tr>
<td>3</td>
<td>Access to Global REN &amp; Internet.</td>
<td>Aggregate international bandwidth</td>
<td>Peaks at 2,700 Mbps. Core backbone currently @ 10 Gbps [Aug 2017]</td>
<td>Google quasi-static content got through local exchange point.</td>
</tr>
<tr>
<td>4</td>
<td>Resilience of local &amp; international routes.</td>
<td>International availability. National availability.</td>
<td>Implemented full redundancy in August 2016, &amp; international uptime in last 6 months = 100%. Exceeded level specified in SLA.</td>
<td>Implemented fully redundant topology with 2 exit points at 2 different PoPs.</td>
</tr>
<tr>
<td>5</td>
<td>Services and Applications to support R&amp;E collaboration</td>
<td>Number of supported tools.</td>
<td>RENU Cloud, Collocation, eduroam, RENU Identity Federation, Capacity building, SSL certificates, Network Monitoring, RENU CERT, Web and Domain Hosting</td>
<td>New internal revenue streams have started.</td>
</tr>
<tr>
<td>6</td>
<td>NE capacity building</td>
<td>Number of NE trained + DEA done</td>
<td>About 8 NE workshops @ 25 trainees + 12 DEAs</td>
<td>RENU expects to attain capacity building autonomy by end of 2017.</td>
</tr>
<tr>
<td>7</td>
<td>NREN Sustainability.</td>
<td>Diversification of Rev. stream + Partnerships + sourcing from local PIP</td>
<td>Started revenue stream from services other than connectivity, 2 new partnerships.</td>
<td>Network expansion funded by internal revenue streams. Presence at UIXP.</td>
</tr>
</tbody>
</table>

Table 1: OPR for the 1–36 months of stand-alone operations of Uganda NREN, i.e. between 2014 and 2017.

Figure 3: Aggregate international bandwidth and average unit price trend (2013 to 2017).
Lessons Learnt

These can mainly be divided into two categories. The first category includes lessons relating to principles and methods of work on the one hand, and the second category has those relating to relationships and human resource on the other.

Category 1:

- For efficient and all-inclusive NREN development, it is important to embark on autonomous operation as early as possible, as opposed to a symbiotic one with a CSP or one where the NREN is run as a government agency.
- In spite of the challenges faced, the path of self-reliance imparts early lessons that strengthen competitive operation, which is a benefit in the long run that yields long-term sustainability.
- In negotiations with PIP and service providers, NRENs should be careful to effectively manage costs, risks and expectations, and steer clear of being locked in uncompetitive agreements. This situation was encountered three times namely with the bandwidth consortium, the dark fibre Indefeasible Rights of Use (IRU) and with the Regional Research and Education Networking (RREN) bandwidth purchase.

Category 2:

- NREN success invariably requires passion and substantial time commitment from team members.
- Close coordination between the Chief Executive Officer (CEO) and Chief Technical Officer (CTO) roles is very useful for NREN progress. Merit is a minimum requirement in making the choice for the individuals for both roles.
- Having the right people (with passion and discipline) at the earliest opportunity is critical for progress, particularly team leaders; to avoid crippling delays and loss of opportunities.
- It became quite valuable to get services from in-country PIPs and CSPs, and it reduced the animosity previously felt by most CSPs towards the NREN, resulting in enhanced symbiotic relationships that yield synergy between industry players and the NREN.

Conclusion

Forging realistic partnerships with commercial services providers is a key factor for realising long-term sustainability of NRENs, as well as improving stability and competitiveness of the ICT sector as a whole.

Identifying and exploiting opportunities for relationships that make business sense to CSPs is one of the prerequisites for unlocking realistic potential for synergies.

Despite being a not-for-profit organisation, RENU aspires for private sector efficiency. RENU adopted a subcontracting model by always evaluating and choosing to work with the best commercial service providers in a given region.

The service providers are always put to task to offer competitive prices and the best possible quality of service. The subcontracting model has helped RENU maintain a thin team while delivering world-class connectivity services. This has greatly helped keep the RENU operating expenses as low as possible.

In the medium term, RENU aims to focus on growing services that support end-user (researchers, academics, students and administrators) needs by cooperatively addressing the exponential pace of ICT capacity-growth required for 21st Century higher education and research.
RENU regularly seeks feedback from its members. In this issue, we bring you interviews from Grace Yiga, ICT Director, Mengo Hospital; Guy Halse, Project Director, South African Identity Federation Project (SAFIRE), TENET; Davis Musinguzi, Managing Director, The Medical Concierge Group; Daniel Mutiah, Head of Heritage International School; and Lloyd Ssentongo, Chairman RENU ICT Directors Forum, all appearing in different parts of this newsletter.
Tell us about yourself; your professional background and area of expertise.

I am an IT professional. I have been in this career for the last 15 years. I started as a software and systems developer, but I'm now involved in planning for ICT activities, acquisition of hardware and software solutions, and overseeing ICT activities in Mengo Hospital.

Tell us about the unique aspects of your institution (Mengo Hospital)

Mengo Hospital is a private not-for-profit institution owned by the church of Uganda. One interesting thing about it is the aggressiveness in changing the mode of service delivery in all aspects of the hospital. For the last three years, there has been a move to change the mode of delivery to match international standards, and ICT is being used as a tool to deliver this move.

Tell us about the different roles played by the ICT Department in supporting various functions of your institution?

The ICT Department plans for the various departments in terms of acquisition of ICT equipment, installation, training the staff in other departments on the use of the equipment, servicing and maintenance of the equipment, and development of simple applications that help these departments to operate. We also interface with the ICT service providers of the hospital e.g. internet service providers, to ensure they are doing the right service for the hospital.

What were the major challenges your ICT Department was facing before becoming part of the NREN (RENU)?

Before joining RENU, the hospital was faced with 2 main challenges; one being the cost of ICT services. Before joining RENU, we were paying about UGX 9,000,000/= (USD 2,500$) for 10 Mbps of internet bandwidth, which was very limiting. The other challenge was that the kind of support we received from the internet service providers we had was not to the standard that we needed. We wanted so much but we were getting so little.

For how long has Mengo been a member of RENU?

We celebrated our 1st anniversary in March 2018.

Tell us about the benefits Mengo Hospital has enjoyed since becoming a member of RENU.

The biggest benefit we have experienced is access to affordable connectivity. We are currently spending less than 40% of the budget we used to spend on connectivity from our previous service providers, and yet we have twice the bandwidth.

The other benefit is in the area of service delivery. We are now able to get very effective support from RENU, and even help from the other RENU member institutions on various issues and the setup of our network or services. All this is possible because of the collaboration that exists among RENU member institutions, and it comes at no extra cost.

Also, our ICT staff have had access to very top-quality trainings. In a period of just one year, we attended 4 trainings and we have already seen the impact those trainings have had on to the ICT service delivery of the hospital!
What more would you like RENU to do that will benefit member Institutions?

This will help us make better use the services that we run on the infrastructure we have setup to benefit our researchers, students and staff. RENU should not be all about affordable internet access. It should be more about what comes with this internet access.

There are tools provided by RENU that we need to work with to help us better our research, get access to research work, get access to publications, get into other works that are done elsewhere to run simulations in labs that are not exactly in our home institutions, labs in other NRENS in the West, where we can run all simulations.

In which aspects do you feel the hospital has gained greatly from RENU’s Direct Engineering Assistance (DEA) program?

Well, there are 3 important benefits. First, as an institution, we received top quality equipment we had been struggling to get because of our limited budget.

Second, RENU helped us rebuild our network to ensure that it is clean and reliable.

Third, our technical team was greatly involved; they learnt very many things while working with RENU engineers - from planning, to physical deployment, to doing configurations, to the way things are actually done right in the market.

Those three benefits brought us to a level where we want our hospital to be in terms of ICT, and more importantly, where our ICT department and the people in ICT really need to be.

The biggest ask we have of RENU is for RENU to help us have better collaboration with other member institutions.

RENU helped us rebuild our network to ensure that it is clean and reliable.

RENU should not be all about affordable connectivity. It should be more about what comes with this.

A RENU-NSRC facilitated DEA in April 2018 at Mengo Hospital
Leveraging RENU Services to Foster Collaboration in Healthcare Service Delivery in Uganda

A Case of Teleradiology

By Julia Nyanzi

Julia is the ICT Manager at Nsambya Hospital where she is the lead person for the digital transformation journey that the Hospital is currently undertaking. Her current research interests are in Enterprise Application Integration, Service Oriented Architecture (SOA) and Business Process Management in the context of improved operational efficiency in healthcare service delivery. Before she joined healthcare IT, she worked in the humanitarian sector with the United Nations World Food Programme as Senior ICT Specialist; Julia has an MSc. in Digital Communications Networks (UK) and a BSc in Electrical Engineering from Makerere University. She is also PRINCE2 and ITIL certified.

Advancement of medical care coupled with complexity of patients’ illnesses today requires a multidisciplinary collaborative approach to treatment. This calls for all clinicians providing patient care to have access to an up-to-date medical record of the patient. One usual barrier to delivering quality patient care is that some specialists whose input to a case is of vital importance may not be physically present in the same geographical location as the patient. Another more severe perspective is in rural Sub-saharan Africa where according to the World Economic Forum in October 2017, “Sub-Saharan Africa accounts for 13% of the world’s population, yet bears 24% of the global disease burden and has only 2% of the world’s doctors.”

Telemedicine solutions have been developed under eHealth systems to address these challenges.

While developed countries are likely to consider legal issues surrounding patient privacy as some of the barriers to telemedicine implementation, for developing countries such as in Sub-
Saharan Africa, it is down to resource issues such as high cost and underdeveloped infrastructure (equipment and/or connectivity).

This article highlights how the high performance yet very affordable telecommunication infrastructure services provisioned by RENU to member institutions can be harnessed for telemedicine and hence collaboration to improve on patient care in Uganda. The article focuses on teleradiology as it is the most mature form of telemedicine and is worth considering for widespread use.\(^2\)

**Development of eHealth and teleradiology**

Supported by the electronic health record, eHealth is the short form of electronic health. Definitions of eHealth abound, varying based on context. The universal themes though are health and information technology, in the context of the healthcare industry and health services delivery, and the Internet. The definition of eHealth by WHO is “the cost-effective and secure use of information and communications technologies in support of health and health-related fields including health-care services, health surveillance, health literature, and health education, knowledge and research.” World Health Organisation (WHO) through a resolution passed at its World Health Assembly in 2005 encouraged more work on eHealth and also urged member states to make an effort to reach communities, including vulnerable groups, with eHealth services. Telemedicine which is an innovation of eHealth has been defined as the use of telecommunication and information technology to provide clinical healthcare from a distance. It has been documented how telemedicine has been used to overcome distance barriers and to improve access to medical services that would often not be consistently available in distant rural communities. Telemedicine has also been used to save lives in critical care and emergency situations.

With the development of medical specialties and diagnostic disciplines, the constantly increasing quantity, diversity and complexity of the data contained in the patient record is noteworthy. The diagnostic discipline under focus here is radiology. Radiology involves the use of medical images in diagnosis and sometimes treatment - imaging techniques used in the medical field include: your conventional x-ray and ultrasound; other techniques include computed tomography (CT), magnetic resonance imaging (MRI), fluoroscopy and under nuclear medicine we have the linear accelerator and positron emission tomography (PET).

The usage of telemedicine in radiology is teleradiology. Teleradiology encompasses a wide range of innovative tools such as Picture Archiving and Communication System (PACS) to improve access to radiology.

The main goal of a PACS is to provide a standardized digital diagnostic image archive, which can be accessed by various users among a defined user community such as within the Hospital over the local area network or even beyond the confines of the Hospital over the internet. Other more recent technology innovations include the incorporation of cloud for redundancy and cost reduction, mobile technologies for greater access and sophisticated teleradiology workflow that enhances radiologist productivity, provides performance metrics and tracks quality.

**Benefits of teleradiology**

The benefits of teleradiology are built around the concept of enhanced access to a Radiologist and probably other subspecialists such as a Neuro Radiologist or a Musculoskeletal Radiologist, remotely. Through teleradiology, the expertise concentrated at one facility can be readily shared. Teleradiology therefore allows for more accurate diagnoses arrived at collaboratively resulting in improved patient care and enhanced efficiency.

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Once the virtual presence of a radiologist is acknowledged through teleradiology, a patient in a rural hospital will through the system have access to radiology reporting and consultation from a remote location. With this arrangement unnecessary travel and

(Endnotes)

1  https://www.weforum.org/agenda/2017/10/digital-paths-for-better-healthcare-in-sub-saharan-africa/
2  WHO Global Observatory for eHealth 2016
expense for the patient and the families is also avoided hence increasing patient access to care.

**RENU services that encourage adoption of teleradiology in Uganda**

It has already been discussed how digitization of the health record – in this case transition from film to digital diagnostic imaging, the need for access to subspecialty consultations and the modern development of computing tools such as PACS has facilitated adoption of teleradiology. It is impossible to talk about teleradiology without referring to the need for reliable and affordable connectivity which unfortunately is a huge challenge in Uganda and other developing countries. Currently the average cost of Internet bandwidth in Uganda is about USD 350 per Mbps per month. This is already a far cry for healthcare institutions even in metropolitan areas as they are already grappling with other high costs of service delivery that are considered as more of a priority. Fortunately, RENU has come in to bridge this connectivity gap for member institutions by providing Internet bandwidth at a cost 5 times lower than the commercial ISP rate. Moreover, there is more to this that member institutions can benefit from – RENU provides a range of other services such as collocation and cloud storage at very subsidised rates. These services which are key ingredients for a reliable teleradiology service are accessible over a high speed (up to 10 Gbps in the metropolis) fibre optic network at no extra cost to the subscribing institutions. With such world class services available with RENU, member institutions in the healthcare industry can comfortably use ICT for collaboration to improve on patient care without worrying about cost.

St. Francis Hospital Nsambya became a member of RENU in April 2018. The Hospital implemented an enterprise PACS solution for its Radiology department close to 2 years ago as the first phase towards implementing a PACS driven workflow and is working towards a teleradiology service in the subsequent phases.
Tell us briefly about TMCG the organisation, the origins, and the problems TMCG set out to solve.

The Medical Concierge Group (TMCG), is a digital health company that connects patients to healthcare providers services via mobile communication technologies. TMCG was founded in 2012 by a group of medical professionals and technologists that were former schoolmates. TMCG is currently located in Uganda (HQ), Kenya and Nigeria.

Many African countries, totalling 1.2 billion people, characteristically have a very low Doctor to Patient ratio, limited diagnostic equipment and rising costs of healthcare, and insurance premiums. As a result, many patients find existing services offered by healthcare providers inaccessible and healthcare payments cumbersome.

You recently made a big decision to migrate to the RENU network. What was the inspiration behind that decision?

Internet connectivity and data management are critical success factors for how TMCG delivers its services. TMCG is constantly involved in clinical research and development in the areas of telemedicine, mobile health, eHealth in partnership with leading universities and research institutions in Uganda, Kenya and around the world. It was timely to learn of RENU’s support to both internet connectivity and cloud solutions for local organisations involved in research. The choice to migrate to RENU was a clear value proposition of both cost-effectiveness, efficiency and reliability for TMCG.

We understand that TMCG has a number of collaborative programs with many RENU member institutions, share with us more on this.

Yes, TMCG has several research collaborations with other RENU members. The most recent being with the Infectious Diseases Institute called Reproductive Health Empowerment through Telehealth (REHEAT). It is a cohort study for men in Uganda with the objectives of delivering user-centered mobile based reproductive health content targeted for men through SMS, interactive voice response, Assessing the feasibility and acceptability of the Men’s Telehealth Information Package (mTIP) on uptake of family planning and reproductive health services, and assessing the impact of the Men’s Telehealth Information Package on uptake of family planning and reproductive health services.

What RENU service(s) do you hope will most benefit your institution?

It is imperative for TMCG to maintain a reliable off-site backup of it’s on premise data warehouse. The most important benefit for TMCG shall be RENU’s cloud-based service that can serve as a fail-over option and an off-premise mirror of TMCG’s data warehouse.

Tell us briefly about the various services TMCG provides?

TMCG provides an end-to-end digital health service initiated with a teleconsultation with its Doctors. This is provided via voice/video calls, a Facebook Chatbot, Whatsapp and SMS. In addition, TMCG remote diagnostic monitoring, mobile money payments for recommended health services, deliveries of medicines, lab sample pick-ups and post-care follow up. This solution is currently at an early growth stage with 30000 active users.
What is the most popular service in the TMCG portfolio?

The live WhatsApp chat service with TMCG’s Doctors is the most active with close to 200 consultations per day.

TMCG recently launched “Mirembe” – an AI health chatbot. Kindly share with us more details on this huge milestone and how it’ll be a game changer in your operations.

TMCG launched AI health chatbot, the first in Uganda and on the African continent!! The new chatbot is personalized as a female personal health advisor named “Mirembe”. She is an African AI health chatbot in Facebook Messenger designed as a symptom checker to make triage recommendations and provide first-line care advice. She is integrated with a request-call-back option at the end of the encounter to link to Medical Doctors at the 24/7 telemedicine call centre of The Medical Concierge Group. This instantly enables us to scale up the number of users we can serve at any one time and provide patient symptom information in advance for a more meaningful teleconsultation.

What have been the biggest challenges TMCG has faced as an organisation to date?

Acquiring and retaining talent across several different areas of expertise is quite challenging as a start-up organisation. Talent is rare and expensive. The alternative is run internship programs and make the investment in professional development to build capacity internally. The other major challenges include funding to grow the organisation. The requirements for equity funding are steep. And lastly, creating the behavioural and cultural shift among patients and healthcare providers to use telemedicine as an effective way to receive and deliver healthcare takes time.

Any other message you have for RENU and the constituent member institutions?

Multi-organisation collaboration and funding in research and development is the only way we can add meaningful value to the innovation ecosystem. We need more of this!!
According to Wikipedia, a federated identity is a means of linking one’s electronic identity and attributes stored across multiple distinct identity management systems. It is the iron age evolution stage of identity management. User credentials and core identity information is centralized and the application only maintains the data that it needs to perform its operations.

It is related to single sign-on (SSO) in which a user’s single authentication ticket, or token is trusted across multiple IT systems or even organizations.

Research and Education (R&E) institutions normally keep disconnected silos of information for access to different applications (multiple logins and passwords) and this normally leads to overhead in duplicated effort and management expenses. Imagine an institution with applications such as email, moodle, dspace, ERP - management of identities is typically disconnected with each application depending on its different identity management system. If new users with privileges to access these services join the institution, identities have to be created for each application. Also, when users leave the institution and access is to be revoked, this has to be done on all the applications.

A federation is a group of organizations (institutions) that agree to operate under legal frameworks, policies (procedures and practices) and standards. It provides the necessary trust and security for exchange of identity information for access to services that are within a federation. The federation may consist of members (Research and Education Institutions - these provide identities and services) and federation partners such as commercial organizations that may only provide services.

RIF is a national identity federation for Research and Education (R&E) institutions in Uganda, and is operated by Research and Education Network for Uganda (RENU). The main technical components of RIF include:

- **Service Provider (SP):** Provides a service (access to applications) based on the IdP provided assertion. It may authorize access to content/applications at Service Provider and can provide service to multiple IdPs.
• **Identity Provider (IdP):** Identity management systems storing the user identity data. It provides the authentication service, asserts user validity and supplies the service provider with the required user attributes. The IdP can provide authentication to multiple service providers.

• **Discovery Service (DS):** Normally called “Where Are You From (WAYF)” service and it provides users with an interface from which they can choose their home institutions. On selecting the home institution, they are redirected to the specific institution login page for authentication.

**Benefits of Identity Federations**

• Reduction in helpdesk queries - the main queries will focus only on identity management. Integration of new services is also significantly simplified.

• Update of application data is guaranteed - there is assurance that users accessing a service shall be using their latest information as the identity system has to be always contacted before service access can be granted.

• The data is pushed to the services hence service compromises will not affect all the user accounts.

• Minimal attack surface area as protection now only focuses on the connection between the IdP and the data store.

• Usability - The authentication process is consistent regardless of the services being accessed.

For more information, visit https://rif.renu.ac.ug/

RIF was established in August 2016. In January 2018, RIF became the 1st Identity Federation in Sub-Saharan Africa (outside South Africa) and the 55th federation in the world, to join eduGAIN.

eduGAIN is an interfederation service that connects identity federations around the world, simplifying access to content, services and resources for the global research and education community. eduGAIN now comprises over 60 participant federations connecting more than 5000 Identity and Service Providers.
Tell us about yourself, your professional background and area of expertise.

I have a university degree in Physics and Computer Science and I went on to do post graduate studies in Computer Science. While I was doing that, I started to work with Rhodes University, and got into systems administration and ultimately became the IT Operations Manager for the university. I’m skilled from fiber optics to identity management and everything in between. Somewhere, I realized that I’m interested in identity, and when an opportunity came up at the South African NREN to head an Identity Federation Project, I seized the opportunity and started working for the NREN. Initially I worked on just identity federation, and now I work on a larger spectrum of trust and identity services. So, my field now is really the trust and identity sphere, which includes identity federation but also other things like certificates and other services.

Tell us briefly about SAFIRE

SAFIRE is the South African Identity Federation. It was established about 5 years ago, and it started as a meeting of all universities in Stellenbosch. There was broad consensus that we needed to start looking into identity federation ideas. It was incubated by the South African Research Network and it took a long time to start actually doing things that made any sense. About 2 years ago, we realized that the reason it was happening is that there wasn’t any shape of it. There was a steering committee but there wasn’t any staff dedicated to the project or any formal structure, money or things that you really need to make a project work. So, it was agreed by the steering committee that TENET be the natural home first, and TENET’s board agreed to take it on as an incubated project, and that ultimately led to my appointment.

The original idea in SAFIRE was always that as a federation we would be able to stand alone and if we wanted to spin it off, we would be able to do it as a tiny company which is why it has a different name. However, the reality is that it is never going to happen or I would be surprised if that happens. So, its current organization is that it’s a service provided by TENET. It’s specially ring fenced by our Board of Directors. It has its own governance rules, somewhat different from the rest of the services we provide, it has a steering committee that is a form of sub-committee of the board. In a very legal sense, its accountability is to the TENET Board of Directors (BoD).

This steering committee has wide powers to make a lot of decisions on how the federation would run, and it consists largely of representatives from the organisations we serve i.e. our membership. It also constitutes the participants forum which consists everyone who has an interest in the federation. The reason for the participants forum is to allow us to gain an understanding of what the community wants. So, from the governance perspective, we have those three tiers – the TENET BoD, the Steering Committee that does day-to-day governance, and the participants forum. And obviously we have some staff – myself and a colleague working on federation stuff as well.

SAFIRE joined eduGAIN in 2017. How has eduGAIN benefited your community and why do you think federations need to join eduGAIN?

eduGAIN was always important to us. Right at the very beginning of SAFIRE, we realized that eduGAIN was something we needed to do. If you look at federations, some of them take a very long time to join eduGAIN, but the truth is that it was always a priority for us. The real reason for that are the research projects that exist in other parts of the world. For example, NIH has collaboration in Uganda, we
also have collaboration with NIH, but also the large hadron collider. Those projects have real researchers with real use cases for federation in South Africa. And so, for us, eduGAIN was always important as a way to connect researchers to those projects that exist in other countries. So, we took a very deliberate strategic direction to focus on building capacity to get eduGAIN working rather than focusing on microservices. We have very few local services but we have a lot of services that we access through eduGAIN. It’s now kind of extended to include library publishers and so we have quite big use cases for accessing library publishers through eduGAIN as well.

What are the challenges SAFIRE has faced?

Interestingly the biggest challenges have never been technical! The technology in federation is complicated but it’s also the easy part. What makes federation challenging is the policy, the politics, the people. We have had challenges in those areas on a number of fronts so in dealing with institutions, we have had a lot of challenges getting institutional lawyers to understand what we are trying to do and getting them to sign off on a contractual basis that makes us able to process user data. We have had challenges in understanding the global federation space - understanding the way global federations build trust. Trust is not built through technology, trust is built through people and understanding the importance of building trust relationships. This is something that was not obvious - we had to figure it out and work on it.

The RENU Identity Federation (RIF) is younger than SAFIRE. From your experience, what do you think young federations should do to encounter fewer challenges on their path to growth?

I think of 2 very important things for emerging federations. First is to keep track of what other federations are doing and why. Follow the conversations that are happening on the mailing lists. That stuff may seem a long way in the future but sometimes it is a lot closer than you think and I will give you an example of that. About 2 years ago, there was a discussion of SIRTFI, which is the Security Incident Response Trust Framework for Federated Identity. A bunch of the very mature federations were talking about needing to have a way of doing incident response in security, and we looked at some and thought it was a good idea, we would make a mental note of it and come back to it in a few years’ time when we were more mature.

Within three months we had an institution that was asking us how to become SIRTFI compliant. So, we have to understand what is going on in the federation space before we start to play in that space. We also have to understand that our researchers are playing in that space too and they have real needs.

The other thing is to participate. This is not a space you can sit back and hope everything will come to you. It’s a space in which if you want to be an active player, you have to participate in the discussions, you have to make an effort to go to the meetings because this is where the trust relationships are built.

Trust is not built through technology, trust is built through people and understanding the importance of building trust relationships.
How much did you know about RENU before your interaction with the RENU team for the workshop in 2018?

I knew a bit about RENU i.e. what sort of network RENU operated and through our interaction with the UbuntuNet Alliance. I knew there are a small handful of NRENS in Africa that are playing in an interesting space.

I also reviewed RENU’s documentation for eduGAIN before RENU was admitted. So, I had some idea that RENU was starting to play in those sorts of spaces, but I didn’t have an idea of the extent of it nor did I have any idea on what was on ground in Uganda.

I could see RENU’s interactions with the global community but not what was happening in RENU’s member institutions. So, what was the interesting bit is understanding what is happening in the universities.

How do you rate the RENU Capacity Building Program with reference to the workshops you have participated in, and in which areas do you think RENU can improve?

I enjoyed the workshop. I think RENU is doing something right if they can get this many people to come and sit together in a room, and more importantly if they can get this many people who know what Federated Identity is. We struggle to get the right people into the room.

We have workshops but often we have managers and people who really are the wrong people to be attending such workshops. So, I think RENU must be doing something right if they can get the kind of people that attended the workshop. To me it’s a very good sign.

Given the opportunity, would you come back and assist RENU?

The answer is yes. It is obvious there are a lot of constraints that come with that but principally I have no problem with the idea and I enjoyed my time.
Introduction

STEM-education is very relevant for East African countries, where producing added value products/goods is a way of improving the standard of living in these developing countries. Moreover, there is a high demand for technicians from investors, NGOs and the emerging middle-class in Ethiopia, Uganda and Tanzania, supported by legislative attempts to increase local employment in these countries.

To cope with this demand, there is a need for skilled people, trained in relevant engineering trades, but they are hard to find, due to the strong theoretical approach used in teaching by most of the universities and other institutions of learning as opposed to practice-oriented competence-based teaching.

Artesis Plantijn University College Antwerp (Belgium) is coordinating the Erasmus+ KA2 Capacity Building Project in the field of Higher Education, *Applied Curricula in Technology for East Africa (ACTEA)* in which a consortium of 6 universities in East Africa and 4 in Europe will work together to develop and implement new courses in technology and engineering in Ethiopia, Uganda and Tanzania. As the focus of the project is on applied sciences, the theoretical content of these courses will be supported by industry-grade lab infrastructure which will be used for hands-on assignments, although remote and virtual labs...
are also envisaged to benefit from it for increased access to learning tools.

**Project Goals**

- To improve the quality of education by changing the theoretical type of learning process in Ethiopia, Uganda and Tanzania to practice-oriented competence-based approach in order to form the competences necessary for the local labor market
- To create practice-oriented curricula, courses and modules in technology
- To create hands-on virtual and remote laboratories
- To speed up integration between Higher Education Institutes (HEIs) and business
- To establish cooperation between EU and target countries in education and research

To ensure relevance for the labor market, a strong cooperation with the local business community and government is set up to assess the local needs for skills and competences and to disseminate the project's results to the wider Community. Because the subjects of the project, namely technology, engineering and skills training are increasingly becoming very relevant in the current economic environment, the project is very open for cooperation through forging synergies with other initiatives.

The ACTEA project aims to meet the specific needs in engineering, provide better and matching skills, deliver course material in 2 specializations (Computer Aided Manufacturing Technology and Electrical Engineering & Automation), establish technologic laboratories with virtual and remote accessibility, develop learning tools, and give academic staff additional training on technology and developing technologic course material according to EU standards. The results will be disseminated and exploited by the train-the-trainer sessions, Masters' Classes and the training of a pilot group of students and external stakeholders. Good practices and results will be made public through e-resources, radio and local media.

The impact in the short term is envisaged to be increased technologic and pedagogic knowledge, increased operational capacity, increase in engineering students, and a better cooperation with the local industry. In the long term, the project aims at an increase in employability, added value for products/goods produced locally, sustained lifelong-learning and long-term high-quality knowledge gain in technology.

The Consortium

- Artesis Plantijn University College Antwerp  Belgium
- Howest – De hogeschool West-Vlaanderen  Belgium
- Fachhochschule Dortmund  Germany
- Technological Educational Institute of Crete  Greece
- Mekelle University  Ethiopia
- Jimma University  Ethiopia
- Mbarara University of Science and Technology  Uganda
- Muni University  Uganda
- Mzumbe University  Tanzania
- Ardi University  Tanzania
- Research and Education Network for Uganda  Uganda
- Tanzania Education and Research Network  Tanzania
You made a big decision to migrate to the RENU network in early 2018. What was the inspiration behind that decision?

The inspiration came from our desire to expand the educational program that we offer to our students, expanding it in a way to leverage the technology tools that are now available here in Kampala and beyond the traditional model of learning.

Tell us briefly about the Heritage International School curriculum and programs that differentiate it from majority of the schools in Uganda?

The Heritage International School curriculum is focussed on our mission of providing a quality international education in a nurturing Christian environment. Our curriculum is truly international in nature. Unlike other schools that follow a single curriculum, we are unique in that we use a selection of curricula from different parts of the world that is regularly evaluated and changed when needed. Our school program is focussed on the learning needs of the student with the goal of helping each student to reach their God given potential. With this in mind, we provide options that allow students to explore and develop in different subject areas, with an emphasis on developing programs that prepare students for a changing world, where technology is becoming ubiquitous. A new unique aspect of our program is our electronic learning environment for our high school students, where students use their own electronic device to access learning resources and collaborate with their classmates and teachers.

We understand the school has a number of collaborative programs with institutions in various parts of the world, share with us more on this.

We have been exploring collaboration using technology both internally and externally. The focus of our external collaboration is to connect with individuals in different parts of the world to enhance student learning. We had a successful video link with a physics professor in Canada who was able to do a question-and-answer session with our physics students. We were also able to do an interactive professional development training session via a video link with a presenter from the US.

We are presently trying to organize another a video link with a commercial communications satellite company to discuss applications of physics principles that our students have learned in their physic lessons. We are also exploring opportunities with a school in Ohio, USA whereby students can collaborate on course related work in ethics, philosophy and world religions. As we explore and expose our school to these opportunities, we hope to expand the opportunities for our students.

With the various collaborations in mind, what role has the RENU network played in helping you achieve your institution’s objectives?

The RENU network provides the necessary infrastructure to make these local and global interactions possible. The RENU network has been instrumental in our high school moving to an electronic environment which allows our students to collaborate with each other and access online learning resources in an effective manner. We are very pleased with the outcome of our partnership.
At the moment, what RENU service(s) is benefitting your institution the most?

Increased internet bandwidth.

In what areas do you feel RENU needs to improve?

The reliability of the network has been very good, but improving it further would be helpful as we are now more dependent on it.

What services would you like to see RENU pay special attention to for the future?

Providing technical support for our network infrastructure development projects.

There does not seem to be a lot of collaboration within RENU member institutions, what do you think can help grow this collaboration?

Sharing of ideas and working together to overcome challenges. A forum to discuss ideas and find solutions would be an asset.

Any other message you have for RENU and the constituent member institutions?

"More is achieved when we work together than when we work alone. We look forward to finding ways of collaborating with the different member institutions."
You have been a part of RENU from the founding days, please give us a brief account of the RENU history.

In 2006, RENU started with a meeting of Vice Chancellors from leading universities in Uganda and very little was talked about the medical and health research institutions from where I come. Initially, they came together to forge a way for facilitating the human networking needed to boost intellectual output and trigger research-led transformation of higher education in Uganda. However, this idea became relevant for other research institutions other than the universities, because of the services that were to come along with the NREN.

Consequently, in 2007, some of the RENU partners then (GMRE, IEEAF, CCGHE and GEO) through the Uganda NIH leadership requested that I coordinate the medical and research institutions and see how to bring them on board. These included NIH, UVRI, CDC, JCRC, MJAP, MildMay, ReachOut Mbuya, MUSPH, MUJHU, IDI, RHSP, TASO, MUWRP, PIDC-Baylor and Mulago Hospital. On October 16th and 17th that year, RENU in collaboration with upcoming NRENs in East, Central and Southern Africa organised a technology conference at Grand Imperial Hotel, Kampala and a follow-up meeting was held in Seattle, Washington on the 28th-30th November 2007

In 2011, the first equipment was installed using UTL fibre, a training of the first RENU core engineering group was done in which I participated. Unfortunately, the network was not used until the AfricaConnect Project came on board to partner with RENU through UbuntuNet Alliance late 2012, and the first member institution Uganda Christian University (UCU) Mukono connected to RENU on 25th February 2014. The network has kept growing since then.

What are RENU’s biggest achievements from the early days till today?

The biggest achievements include;

- The various research and educational institutions coming on board to grow the network. The number of Institutions subscribing to RENU services has grown rapidly and is continuing to grow steadily. Just within a period of less than 5 years, RENU has attracted a total of 71 Institutions and has connected a total of 125 campuses belonging to these institutions.

- The capacity building program being implemented by RENU in collaboration with NSRC which has helped a lot in improving the skills of the network engineers at the RENU member institutions. This has also led to improved performance of the networks.

- RENU being officially recognized in January 2016 as the 75th National Roaming Operator (NRO) for eduroam in the world, and being among the first 5 NRENs in Africa to implement eduroam.
✓ The traffic local to member institutions is free within the RENU network, an experience that wouldn’t be possible with commercial providers.

✓ The RENU Identity Federation (RIF) becoming the 55th federation in the world to join eduGAIN, and the 1st in sub-Saharan Africa outside South Africa.

✓ Effective mid-2018, all leased lines for member institutions became free. This meant that for an institution like the one I represent with 3 sites and over 100 kms apart, the connectivity cost amongst them reduced to zero and at the same time users are able to share and access resources across securely.

What services does your institution get from RENU?
- Leased line point-to-point services from Kampala to Entebbe to Kalisizo offices.
- Affordable and reliable Internet connectivity
- NTP
- DNS
- eduroam
- Federation and identity access management
- Sizeable IPv4 address blocks

In what areas do you feel RENU needs to improve?
More sensitization to member institutions on what an NREN is and the various services that there are to benefit from as member institutions; providing user-driven capacity building programs; more strengthening of the collaboration between the member institutions; and upgrading all in-country fibre circuits connecting institutions to 10 Gbps, and probably 100 Gbps in the next 5 years.

What services would you like to see RENU pay special attention to for the future?
Unfortunately, despite the efforts RENU has put in, less than 5 institutions are currently using this service and I feel special attention needs to be given to this.

Tell us briefly about the collaboration initiatives that your institution is involved in and how RENU continues to play a role in this collaboration.

The NIH ICER in Uganda has been collaborating with Rakai Health Sciences Program (RHSP) for the last 20 years and hundreds of publications have been published by RHSP through various journals worldwide. Using the RENU federated identity service, users at RHSP are able to use their organisational identities “xyz@rhsp.org” to access these journals through the NIH library at no cost. The ability for scientists to access these journals easily has positively impacted on the performance of the research.

RENU has built a 1 Gbps backbone that connects many of the R&E institutions in Uganda to one another and to other regional and national RENs around the world such as GÉANT in Europe and Internet2 in the United States. The ACE partnership and center will work to provide reference databases and compute infrastructure across the RENU backbone without needing to use internet gateways.

The National Institute of Allergy and Infectious Diseases (NIAID) and the NIH have established a public-private partnership with private industry, the Research and Education Network of Uganda (RENU), Makerere University and the Infectious Diseases Institute of Uganda to build the second African Center of Excellence in Bioinformatics in Kampala, Uganda (ACE).
databases, and local support services for data science will improve the educational and analytical capacity of researchers in Uganda and improve the quality of their collaborations with scientists in the United States and elsewhere.

There does not seem to be a lot of collaboration among RENU member institutions, what do you think can help grow this collaboration?

Like I mentioned above, this is one of the areas that needs to be improved on, and some of my thoughts are:

- Many member institutions seem not to understand what a NREN is and the benefits of being a member. RENU needs to do more sensitization on this.
- The various forums "ICT Directors, Vice Chancellors, Librarian and Researchers’ forums "need to be meeting more frequently than they are doing and possibly hold joint meetings may be quarterly or annually.
- RENU needs to engage the user community to find out there needs and address them as well.

Any other message you have for RENU and the constituent institutions?

"RENU, its partners, collaborators and member institutions have all contributed tremendously to the growth and success achieved so far. I am only hoping the spirit continues."
The RENU Industrial Training Program

The Experience

Every year, RENU conducts industrial training for university students. Below, we bring you what the beneficiaries say about the training program.

Caroline Namuddu

My experience at RENU started way before I officially stepped at the RENU premises as a pioneer industrial trainee! I was extremely privileged to partake in the maiden intake of industrial trainees at RENU. This experience started with the rigorous and impartial application process that serves to also determine how much you desire to work with them.

Given the fact that we had to write resumes and also indulge in interviews, it was only expected of us to learn even more about RENU. The realization of what it is only served to increase my desire to be a part of their industrial training program. The organisation exhibited in the application process showed me the level of order expected when one is enrolled.

Finally, I saw the email summoning me for interviews in my inbox. That day was filled with anxiety as the mind could not properly determine whether to be happy, worried to mention but a few. The interviews were nothing short of tasking and indulging. The questions asked were straight to the point and as technical as they come as opposed to the usual general life questions asked by other organisations.

With the promise to hear from them, I patiently waited for any form of communication which came sooner than later. With the email confirming my placement, I could barely wait to arrive. Along with the email came a google document indicating the program set out for us.

No sooner had I arrived than we were briefed in the nitty gritties of what we were going to do, what was expected of us and all supporting information. We were carefully introduced to all the staff members by the Chief Technical Officer. He as well thoroughly took us through the theory behind the work done at RENU. With this briefing, we were each allocated fields to read from which we would subsequently present about twice every week to the CTO and await his correction and guidance. This served to build our confidence not just in matters of presenting to people but also the confidence of knowing what it is one is doing.

During this internship, I was exposed to a multitude of theoretical and even more practical experiences. For a computer engineering student such as myself, this molded a deep appreciation for system administration, internet and computer networking.

In a nutshell, this program enlightened me on a spectrum of skills. The care exhibited through the allowances galvanized my stay even more hence giving a wholesome experience. This is by far the best learning experience I have undertaken and do hope every capable person can acquire this experience.
Jonathan Rukundo – An ICT Support Officer at Bank of Africa – Uganda Ltd, Freelance Website Designer and a Community Volunteer

“Prior to this training, I felt that I had no idea where my career was going and I lacked confidence about what I could do and what I am really good at. The two months I spent at RENU saw me interact with a number of people, and this availed me an opportunity to amass a number of vital skills especially in the IT field. I definitely derived a better understanding of my skill set and where my career may take me.

“RENU under promised but over delivered when it came to this industrial training, since most of my expectations were overwhelmingly exceeded”

William Kibirango – An undergraduate computer engineering student at Makerere University

“When I got accepted to train at RENU, I had a goal to strengthen my understanding on networking, the cloud, and using GNU/Linux to solve real-world problems. I also wanted to learn how to work well with other people on projects because I know that it is a very important skill to have. I can confidently say that RENU has helped me meet my goals!”

“RENU has provided me and my fellow trainees with skills that are both cool and marketable”

Daniel Kawuma – An undergraduate software engineering student at Makerere University.

“From the advice offered by a few of my friends, I decided to pursue bachelor’s degree in software engineering. With all this happening, I did not know what I wanted to do with the course until Third year, when I joined The Research and Education Network for Uganda (RENU) for my industrial training that started in July to August 2018. During this period, I learned how to channel the different skills and abilities, that I had acquired in my study program for the past three years, into different areas in the technology environment. With RENU, I realized that I had chosen the right course that would enable me impact the network world positively.”

Arthur Tumwesigye – An undergraduate telecommunications engineering student at Makerere University

“The assignments I performed during my internship allowed me apply my university learning in a real-world environment. I would highly recommend RENU for future internship programs as I am certain that the insights I have gained from there would definitely benefit me and any other student who is about to enter the working world.

Such an organisation is a good ground to test a student’s ability to think critically, analytically and also exhibit professionalism, all of which are characteristics universities are always striving to instill in their students.
A Collaborative Approach to Network Monitoring and Performance Fine Tuning

By Caroline Namuddu & Ronald Matovu

The research and education community in Uganda base many of their operations on local, regional and international networks, partners and stakeholders each with separate policies, hardware and configurations. These heterogeneous sets of networks must operate seamlessly to ensure meaningful collaboration, which collaboration often flourishes with high-performing global networks.

The data involved in these collaborations includes academic, medical, geographical and other forms of research data and is often collected, processed, stored and retrieved at geographically and topologically separated facilities. This poses a question on the status of the paths between these administratively different domains.

RENU has deployed many network monitoring tools that have eased the view into the real-time status to every edge of the network. This has helped in troubleshooting, and therefore guaranteed excellent service delivery. The tools however do not look beyond the RENU network to clearly monitor the health of other partners and collaborators' networks. This therefore exposed the need for tools that could provide visibility into the other administratively different domains.

PerfSONAR

On 19th August 2016, RENU deployed two PerfSONAR nodes joining a worldwide network of probes. perfSONAR (Performance focused Service Oriented Network monitoring ARchitecture) is an open source tool that enables network performance information

Caroline Namuddu
Caroline Namuddu is a NOC Support Engineer at RENU. She offers first line support to all member institutions at RENU. Caroline holds a Bachelor's degree in Computer Engineering from Makerere University. She was a beneficiary of the RENU Industrial Training.

Ronald Matovu
Ronald Matovu is a NOC Support Engineer at the Research and Education Network for Uganda (RENU). He holds a Bsc. Computer Engineering (First Class Honors) from Makerere University. He graduated best in his class and was a beneficiary of the RENU Industrial Training Program 2017/2018.

perfSONAR enables ubiquitous gathering and sharing of performance information to simplify management of advanced networks and facilitate cross-domain troubleshooting.
to be gathered and exchanged in a multi-domain, federated environment. perfSONAR enables ubiquitous gathering and sharing of performance information to simplify management of advanced networks and facilitate cross-domain troubleshooting.

perfSONAR was initially developed after a partnership between ESnet, GÉANT, Indiana University, Internet2 and University of Michigan. Several other organisations have joined the initial partners and are contributing to further development and deployment of perfSONAR.

Installation

perfSONAR requires dedicated hardware most preferably server-class hardware considering virtual machines do not work well as perfSONAR hosts. perfSONAR also requires CentOS as the Operating System (OS) since it is a lightweight, fast, secure and reliable OS.

After installation many services will start without direct intervention while others need some minor configuration.

How it works

The perfSONAR architecture is organized in different layers each responsible for a unique function. This can be shown in the graphic below.

Tools - This layer includes all of the network performance measurement commands run by the perfSONAR server. They are categorised in three;

1. Throughput tests - iperf3, iperf, ntttcp.
2. Latency and packet loss tests - ping, One-Way Active Measurement Protocol (OWAMP) that measures unidirectional characteristics such as one-way delay and one-way loss.
3. Traceroute tests - traceroute, tracepath, paris-traceroute

Scheduling - The `pscheduler` is responsible for scheduling the tasks to be run periodically on the network. It also unifies and harmonises the execution of tools or tests.

Archiving - At this layer, software modules are responsible for archiving measurements. `Esmond` runs a hybrid type database. Real-time data logged by perfSONAR tests is saved on a R&D database and displayed as graphs in the upper layer. Metadata such as interface description and interface types from SNMP are stored in an SQL database.

Configuration - `MeshConfig` is responsible for simplifying the configuration and update of tests running on multiple perfSONAR hosts.
Visualization – **MaDDash** is the dashboard used to visualize the test results in a two-dimensional grid between two nodes.

**Discovery** - The Lookup Service Registration is used by hosts to build a dynamic list of hosts that can be used as testing endpoints depending on the set configuration types.

**Deployment**

A perfSONAR node can be placed anywhere in the network especially where it serves a bigger need to network operators, users and the entire community. The model of deployment also depends on the use case to be adopted. Three different use cases exist;

1. **Beacon** - Here the node is made available for others to test against.
2. **Island** - Stands alone but is configured to test to other beacons, islands and mesh members by the maintainer.
3. **Mesh** - involves coordinating several nodes via a shared configuration file that describes a test. The tools read the configuration file, perform the test and store the results individually or in a central location.

It is highly recommended that different network interfaces or even nodes be used for the different tests as testing both Bandwidth and Latency simultaneously on a single interface impacts test accuracy.

**Measurements**

perfSONAR allows users around the world to configure tests to other measurement points using built-in services. Built-in graphs can be viewed after proper configuration to show performance over time.

Following the installation and configuration of the two perfSONAR nodes in the RENU network, we have run several tests and used the results to better our understanding of the health status of the paths to several critical resources and infrastructure serving individual members and the entire research and education community in Uganda.

The graph here shows results of tests between two perfSONAR probes. It shows the latency, packet loss and throughput over a period of one month.

A lot of information is drawn from such test results, and this can be used to make informed decisions towards fine tuning the network.

**RIPE ATLAS**

Like the name states, RIPE Atlas is a global network of probes that actively measure Internet connectivity and reachability.

RIPE ATLAS entirely depends on thousands of volunteers around the world to host probes and anchors on their networks. Since 2010, the RIPE Network Coordination Centre (NCC) has distributed over 19,000 probes throughout the world.

The probes run in built measurements whose data the RIPE NCC collects and publicly provides Internet maps, tools and visualisations based on the aggregated results.
The platform can be really helpful in troubleshooting network issues, especially finding loss points in the paths to certain targets. After a fault occurrence pattern has been established, one can schedule measurements for an insight into the cause of fault.

The RENU NOC monitors network reachability to different vantage points and vice versa around the globe. These points are carefully selected to represent a good percentage of partners and collaborators with RENU member institutions.

Results of the tests are critically analysed to determine optimal paths to the intended resources hence guaranteeing better user experience.

One of the benefits of hosting a probe or anchor is that one can acquire credits which are used to perform User Defined Measurements (UDM). These are custom made measurements that can be scheduled to run at any time to any target. RENU hosts a probe (ID 30014) which continuously performs in built measurements. Some of these measurements include targeting the Internet’s critical infrastructure like the root DNS. The picture below shows a Ping measurement (#1012) to the D root server managed by University of Maryland which is cached at the UIXP.

From the picture we notice a variation in RTT from less than 2 ms to over 180 ms as result of a temporary shutdown of the UIXP on the 19th of February 2019.
RENU Financial Report for the Year Ended 31st December 2018
STATEMENT OF DIRECTORS' RESPONSIBILITIES

The Companies Act, 2012 requires the directors to prepare financial statements for each financial year which give a true and fair view of the state of affairs of the Company as at the end of the financial year and of its profit or loss for that year. It also requires the directors to ensure that the Company keeps proper accounting records that are sufficient to show and explain the transactions of the Company; and that disclose, with reasonable accuracy, the financial position of the Company and that enables them to prepare financial statements of the Company that comply with the International Financial Reporting Standard for Small and Medium sized Entities and the requirements of the Ugandan Companies Act, 2012. The directors are also responsible for safeguarding the assets of the Company and for taking reasonable steps for the prevention and detection of fraud and other irregularities.

The directors accept responsibility for the preparation and fair presentation of the financial statements in accordance with the International Financial Reporting Standard for Small and Medium sized Entities and in the manner required by the Companies Act, 2012. They also accept responsibility for:

i. designing, implementing and maintaining such internal control as they determine is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error;

ii. selecting and applying appropriate accounting policies; and

iii. making accounting estimates and judgments that are reasonable in the circumstances.

The directors are of the opinion that the financial statements give a true and fair view of the financial position of the Company as at 31st December 2018 and of it’s financial performance and cash flows for the year then ended in accordance with International Financial Reporting Standard for Small and Medium-sized Entities and the requirements of the Companies Act, 2012.

In preparing these financial statements the directors have assessed the Company's ability to continue as a going concern. Nothing has come to the attention of the directors to indicate that the Company will not remain a going concern for at least the next twelve months from the date of this statement.

The directors acknowledge that the independent audit of the financial statements does not relieve them of their responsibilities.

So far as each of the directors is aware, there is no relevant audit information which the auditor is unaware of, and each of the directors has taken all the steps that ought to have been taken in order to become aware of any relevant audit information and to establish that the auditor is aware of that information.
REPORT OF THE INDEPENDENT AUDITOR TO THE MEMBERS OF THE RESEARCH AND EDUCATION NETWORK FOR UGANDA

Opinion

We have audited the financial statements of The Research and Education Network for Uganda which comprise the statement of financial position as at 31st December 2018, the statement of profit or loss and accumulated fund and statement of cash flows for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements give a true and fair view of the financial position of the company as at 31st December 2018, and of its financial performance and cash flows for the year then ended in accordance with the International Financial Reporting Standard for Small and Medium-sized Entities (IFRS for SMEs) and the Companies Act, 2012.

Basis for opinion

We conducted our audit in accordance with International Standards on Auditing (ISAs). Our responsibilities under those standards are further described in the auditor’s responsibilities for the audit of the Financial Statements section of our report. We are independent of the Company in accordance with the International Ethics Standards Board for Accountants Code of Ethics for Professional Accountants (IESBA Code) together with the ethical requirements that are relevant to our audit of the financial statements in Uganda, and we have fulfilled our other ethical responsibilities in accordance with these requirements and the IESBA Code. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Other information

The directors are responsible for the other information. The other information comprises the directors’ report and the schedule of cost of sales and other operating expenditure but does not include the financial statements and our auditor’s report thereon.

Our opinion on the financial statements does not cover the other information and we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial statements, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial statements or our knowledge obtained in the audit, or otherwise appears to be materially misstated. If, based on the work we have performed, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Responsibilities of directors for the financial statements

The directors are responsible for the preparation of the financial statements that give a true and fair view in accordance with IFRS for SMEs and the requirements of the Ugandan Companies Act, 2012, and for such internal control as the directors determine is necessary to enable the preparation of financial statements that are free from material misstatement, whether due to fraud or error.

In preparing the financial statements, the directors are responsible for assessing the Company’s ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the directors either intend to liquidate the Company or to cease operations, or has no realistic alternative but to do so.
REPORT OF THE INDEPENDENT AUDITOR TO THE MEMBERS OF THE RESEARCH AND EDUCATION NETWORK FOR UGANDA (CONTINUED)

Auditor’s responsibilities for the audit of the financial statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor’s report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with ISAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with ISAs, we exercise professional judgment and maintain professional skepticism throughout the audit. We also:

• Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

• Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the Company’s internal control.

• Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by the directors.

• Conclude on the appropriateness of director’s use of the going concern basis of accounting and based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt on the Company’s ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor’s report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor’s report. However, future events or conditions may cause the Company to cease to continue as a going concern.

• Evaluate the overall presentation, structure and content of the financial statements, including the disclosures, and whether the financial statements represent the underlying transactions and events in a manner that achieves fair presentation.

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.
REPORT OF THE INDEPENDENT AUDITOR TO THE MEMBERS OF THE RESEARCH AND EDUCATION NETWORK FOR UGANDA (CONTINUED)

Report on other legal and regulatory requirements

As required by the Companies Act, 2012 we report to you, based on our audit, that:

(i) we have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit;

(ii) in our opinion proper books of account have been kept by the Company, so far as appears from our examination of those books; and

(iii) the Company's statement of financial position and statement of profit or loss and accumulated fund are in agreement with the books of account.

The engagement partner responsible for the audit resulting in this independent auditor's report is CPA Frederick Kibbedi who holds practicing license number - P0242
## STATEMENT OF PROFIT OR LOSS AND RETAINED EARNINGS

<table>
<thead>
<tr>
<th>Description</th>
<th>2018 Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
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</thead>
<tbody>
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<td>Revenue</td>
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<td>6,877,035,607</td>
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<tr>
<td>Cost of sales</td>
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<td>(4,942,802,913)</td>
<td>(5,027,426,123)</td>
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<td><strong>Operating surplus</strong></td>
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<td>2,963,191,883</td>
<td>1,849,609,484</td>
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<tr>
<td>Other income</td>
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<td>37,724,636</td>
<td>61,664,478</td>
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<td>Foreign exchange gain</td>
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<td>50,590,040</td>
<td>3,673,781</td>
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<td>Employment Costs</td>
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<td>(1,034,651,955)</td>
<td>(679,676,904)</td>
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<td>Administrative expenses</td>
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<td>(895,468,874)</td>
<td>(638,231,430)</td>
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<td><strong>Surplus before tax</strong></td>
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<td>Tax charge</td>
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<td>[122,564,570]</td>
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<td><strong>Surplus for the year</strong></td>
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<td>474,474,839</td>
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<td>Retained earnings at the start of the year</td>
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<td>1,814,831,856</td>
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<td>Restatement of Reserves</td>
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<td>Profit for the year</td>
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<td>474,474,839</td>
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<tr>
<td><strong>Retained earnings at the end of the year</strong></td>
<td></td>
<td>2,418,884,854</td>
<td>1,814,831,856</td>
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Report of the independent auditor - pages 62 to 64
# STATEMENT OF FINANCIAL POSITION

<table>
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<th>Notes</th>
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<th>2017</th>
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<tbody>
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<td><strong>EQUITY</strong></td>
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<tr>
<td>Retained earnings</td>
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<td>1,814,831,856</td>
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<tr>
<td><strong>Non-current liability</strong></td>
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<tr>
<td>Deferred Tax liability</td>
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<td><strong>Represented by</strong></td>
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<td><strong>Non-current assets</strong></td>
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<td>Property and equipment</td>
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<td>Intangible assets</td>
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<td><strong>Current assets</strong></td>
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<td>Trade and other receivables</td>
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<td>Cash and cash equivalents</td>
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<td>Tax recoverable</td>
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<td><strong>Current liabilities</strong></td>
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<td>Trade and other payables</td>
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<td>709,875,298</td>
<td>567,064,275</td>
</tr>
<tr>
<td>Deferred Income</td>
<td>12</td>
<td>344,280,362</td>
<td>327,791,047</td>
</tr>
<tr>
<td>Tax payable</td>
<td></td>
<td>45,237,861</td>
<td></td>
</tr>
<tr>
<td><strong>Net current assets</strong></td>
<td></td>
<td>1,099,393,521</td>
<td>894,855,322</td>
</tr>
</tbody>
</table>

Report of the independent auditor - pages 62 to 64.
# STATEMENT OF CASH FLOWS

## Cash flows from operating activities

<table>
<thead>
<tr>
<th>Description</th>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surplus before tax</td>
<td></td>
<td>1,121,385,730</td>
<td>597,039,409</td>
</tr>
<tr>
<td><strong>Adjustments for:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation on property and equipment</td>
<td>13</td>
<td>334,586,746</td>
<td>313,566,480</td>
</tr>
<tr>
<td>Depreciation on restated amounts of property and equipment</td>
<td></td>
<td>(10,147,465)</td>
<td></td>
</tr>
<tr>
<td>Amortisation of intangible assets</td>
<td></td>
<td>1,542,420</td>
<td></td>
</tr>
<tr>
<td>Loss on disposal</td>
<td></td>
<td></td>
<td>4,061,635</td>
</tr>
<tr>
<td>Prior year adjustments</td>
<td></td>
<td></td>
<td>86,333,871</td>
</tr>
<tr>
<td><strong>Changes in working capital:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inventory</td>
<td></td>
<td>(67,083,579)</td>
<td>102,615,808</td>
</tr>
<tr>
<td>- trade and other receivables</td>
<td></td>
<td>(883,955,903)</td>
<td>(320,020,638)</td>
</tr>
<tr>
<td>- trade and other payables</td>
<td></td>
<td>142,811,023</td>
<td>4,526,475</td>
</tr>
<tr>
<td>- Deferred income</td>
<td></td>
<td>16,489,315</td>
<td>(12,114,303)</td>
</tr>
<tr>
<td>Tax paid</td>
<td></td>
<td>(286,217,535)</td>
<td>(140,000,000)</td>
</tr>
</tbody>
</table>

**Net cash generated used in operations**

<table>
<thead>
<tr>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>369,410,753</td>
<td>636,008,737</td>
</tr>
</tbody>
</table>

## Cash flows from investing activities

<table>
<thead>
<tr>
<th>Description</th>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of property and equipment</td>
<td>13</td>
<td>(510,579,221)</td>
<td>(270,517,659)</td>
</tr>
<tr>
<td>Purchase of intangible asset</td>
<td>14</td>
<td>(30,848,400)</td>
<td></td>
</tr>
</tbody>
</table>

**Net cash used in investing activities**

<table>
<thead>
<tr>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(541,427,621)</td>
<td>(270,517,659)</td>
</tr>
</tbody>
</table>

## Decrease in cash and cash equivalents

<table>
<thead>
<tr>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(172,016,868)</td>
<td>365,491,078</td>
</tr>
</tbody>
</table>

## Movement in cash and cash equivalents

<table>
<thead>
<tr>
<th>Description</th>
<th>Notes</th>
<th>2018 Ushs</th>
<th>2017 Ushs</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the start of the year</td>
<td></td>
<td>517,789,348</td>
<td>152,298,270</td>
</tr>
<tr>
<td>Decrease/increase in cash and cash equivalents</td>
<td></td>
<td>(172,016,868)</td>
<td>365,491,078</td>
</tr>
<tr>
<td>At end of year</td>
<td></td>
<td>345,772,480</td>
<td>517,789,348</td>
</tr>
</tbody>
</table>

Report of the independent auditor - pages 62 to 64.
A national research and education environment in which Uganda's researchers and scholars effectively contribute to knowledge creation, dissemination and application in solving society's problems through local and international collaboration.
Mission

To facilitate collaboration among Uganda’s research and education institutions for knowledge creation, sharing and utilisation, through the provision of advanced networking and other advanced technical services.