Transformation-Ready: The strategic application of information and communication technologies in Africa

FINAL

Education Sector Study

Annex 6: National Research and Education Networks

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1 Introduction

National Research and Education Networks (NRENS) play the key role of providing dedicated broadband connectivity to support primarily university level research and education institutions, and increasingly to extend connectivity to lower level educational institutions[1] as well as other non-government non-commercial institutions that play a public good role. These include libraries, hospitals, and museums. Many countries also use them as a vehicle to provide connectivity and other support to lower level education institutions[2]. These come with their own sets of needs and challenges that need to be addressed[3].

As the need for collaboration extended beyond national borders, countries, typically within the same geopolitical spheres, create regional overlays, the Regional Research and Education Networks (RRENs), which enable collaboration across national borders. Internet2[4] and the National Lambda Rail[5], for example interconnect the state research and education networks in the USA; GÉANT[6] interconnects NRENs in the EU; CLARA[7] interconnects NRENS in South America; and UbuntuNet Alliance[8] has started interconnecting NRENs in Eastern and Southern Africa.

All developed countries, and now most developing countries around the world, have NRENs. Africa however lags very significantly behind. More than 60% of the African countries do not have NRENS.

This report scans the global NREN environment and discusses NRENs and their motivation as well as the role they play in supporting the education sector, bringing out examples that can guide the development of African NRENs as well as the opportunities and challenges such NRENs face in Africa. The major focus is on NRENs as key components of an etransformation ready education sector in Africa.

[1] http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1181699473021/3876782-1191373775504/indiainnovationchapter6.pdf
[2] http://siteresources.worldbank.org/SOUTHASIAEXT/Resources/223546-1181699473021/3876782-1191373775504/indiainnovationchapter6.pdf
[3] http://www.terena.org/publications/files/EARNEST-OthersUsers-Report.pd
[4] http://www.internet2.edu/
[5] http://www.nlr.net/
[6] www.dante.net
[7] www.redclara.net
[8] www.ubuntunet.net

2 Landscape Analysis

2.1 The Motivation for NRENs

A major driver of NRENs is the inadequacy of the commercial internet in addressing, on demand, the often specialised needs and very high bandwidth requirements of the global research community.

NRENs enable the sharing of content that includes digital learning content; sharing of applications and resources (expert human resource; e-learning platforms; management information systems; remote laboratories accessed through the internet (i-labs); video-conference platforms; computers; etc); and implementation of advanced applications as well as access to high bandwidth capacity on demand.

Working together as NRENs has also positioned universities and research institutions to have higher negotiating power when dealing with governments, regulators, the private sector, and development partners. It actually creates a win-win situation for all, enabling the achievement of both development and commercial objectives with much lower operating overheads. This is enhanced by the fact that NRENs are non-profits and are bound by a code, the Acceptable Use Policy (AUP) that ensures that grant funding and other privileges are not used to disadvantage the private sector.

In his blog, Louis Fox who has been long involved in the Pacific North-West Gigapop as well as the K20 programme probably captures it most concisely in his blog in Annex 10:

> *"NRENs serve many functions. They create leading-edge network capability for the international research community; they enable revolutionary Internet applications; they ensure the rapid transfer of new network services and applications to the broader Internet community; they provide a platform for sharing scientific (and other) applications and resources; they aggregate demand for bandwidth and thereby create "buying clubs," drive down the cost of bandwidth; and they create social value by including communities outside their primary research university constituencies, like primary and secondary schools, libraries, museums, scientific and cultural institutions. In order to flourish, NRENs must focus on the technical dimensions of data networks and they must also attend to the human dimension, the creation of shareable expertise for support and collaboration across many fields of research and education".*

The EUMEDConnect2 website has compiled a selection of perspectives from experts and practitioners on the importance and role of NRENs[9], some of which are reproduced below.

> *"R&E networks are high-speed data-communications networks that are independent of the commercial internet and are dedicated to meeting the needs of the academic and research communities. They allow researchers, teachers and students to share information electronically in a reliable and timely fashion and to work together effectively".*

[9] http://www.eumedconnect2.net/server/show/ConWebDoc.3304#1

"By definition, the research community pushes at the boundaries of our knowledge. Researchers and students use the most advanced tools, techniques and applications to exchange and process often very high volumes of time-critical data quickly and efficiently. They rely on the network to provide greater speeds, timely delivery and a very high level of resilience. Connections must be reliable and delivery defined"

"To improve the way we deal with disease, disasters and other natural challenges, we need to understand more about our world - how it works and how it's changing. If we're going to make life better for people, we have to learn to share our knowledge and our skills. The answer lies in working together effectively. R&E networking is important because it provides a platform that enables better cooperation, collaboration and integration within and between geographically dispersed research and education communities."

"…R&E networking is not just about helping 'big science'. At a local level, students in physically remote parts of North Africa and Asia gain access to a better quality education experience over their new connections. By overcoming the barriers to education, e-learning can provide new and life-changing opportunities for students. For example, thanks to stable videoconferencing, students in Palestinian universities can now enroll on courses and participate remotely and interactively in lectures held anywhere in the world…"

"You get a better idea of the potential health and social benefits that R&E networks can deliver if you look at a few tele-medicine applications. Doctors can consult expert colleagues anywhere in the world to diagnose patients who are then treated where they live. Patients avoid the time and cost of travel for treatment because expertise can be provided where it is needed. Some 50 million people, for example, suffer from epilepsy but many are resistant to drug therapies. Treating epilepsy with surgery is complex, however R&E networks allow neurosurgeons in Tunisia, for example, to consult colleagues in France on patient assessment whilst remote training equips them with new surgical skills."

It is clear that NRENs have a need for existence and benefits outside the commercial cloud. All NRENs around the world receive direct or indirect government support, underscoring the recognition of governments that NRENs have a crucial role to play in education and development. Where the private sector is advanced, they affiliate with NRENs and support them in recognition of the mutual benefits:

i. NRENs provide the environment, intellectual capital, and test beds for advanced techniques and applications that drive cutting edge technology in the commercial sector;

ii. NRENs grow the future business of the commercial sector by creating environments in which students get used to high bandwidth and advanced applications environments. They will have the same demands as paying customers.

While NRENs do have their independent networks, they are not isolated from the commercial cloud: all NRENs must establish peering relationships with commercial providers for purposes of exchanging traffic. A defining aspect of the operation of NRENs, put in place to ensure that they do not compete with commercial service providers, is incorporated in the Acceptable Use Policy (AUP) that all NREN institutions are required to abide by: one end of any transmission

(i.e., originating or receiving) handled by NRENs ***must*** be someone within the education and research community. In other words, NRENs cannot transit non-NREN traffic.

2.2 The Structure of NRENs

The structure of the global research and education community can be examined from two perspectives: one focuses on the progressive build up of connecting organisations and infrastructure while the other looks at the inanimate and animate sides of the structure.

NRENs start at the campus level. Campuses therefore need to have high quality data networks, sufficient user devices for user access, and competent human resource to assure the availability and integrity of both the network and the content it provides access to. At the national level, these campus networks are inter-connected using a high speed data backbone to form the National Research and Education Network – such as the Joint Academic Network (JANET)[10] in England or the Kenya Education Network Trust (KENET)[11] in Kenya. As the need for collaboration extends beyond national borders, NRENs, typically within the same geopolitical spheres, create regional overlays, the Regional Research and Education Networks (RRENs) which enable collaboration across national borders. Internet2[12] and the National Lambda Rail,[13] for example interconnect the state research and education networks in the USA, GÉANT[14] interconnects NRENs in the European Union, CLARA[15] interconnects NRENS in South America, and UbuntuNet Alliance[16] has started interconnecting countries in Eastern and Southern Africa. The regional networks, connected together, form the global research and education network, serving the global research and education community.

NRENs can also be envisaged as having two layers:

i. Inanimate: The data network transport and application layer, consisting of high speed data networks interconnecting the member institutions, the applications that run on this network, and the shared access to resources permitted by this layer; and

ii. Animate: The human layer where content sharing and collaboration (in research and education) occur.

Each of these layers presents its own challenges. The network transport and applications layer is all about technology and, given the right human capacity and resources, can always be addressed. The human layer, where the real benefits occur, is the most challenging because it is built on trust and a willingness to collaborate, both of which cannot be forced.

[10] www.ja.net
[11] www.kenet.or.ke
[12] http://www.internet2.edu/
[13] http://www.nlr.net/
[14] www.dante.net
[15] www.redclara.net
[16] www.ubuntunet.net

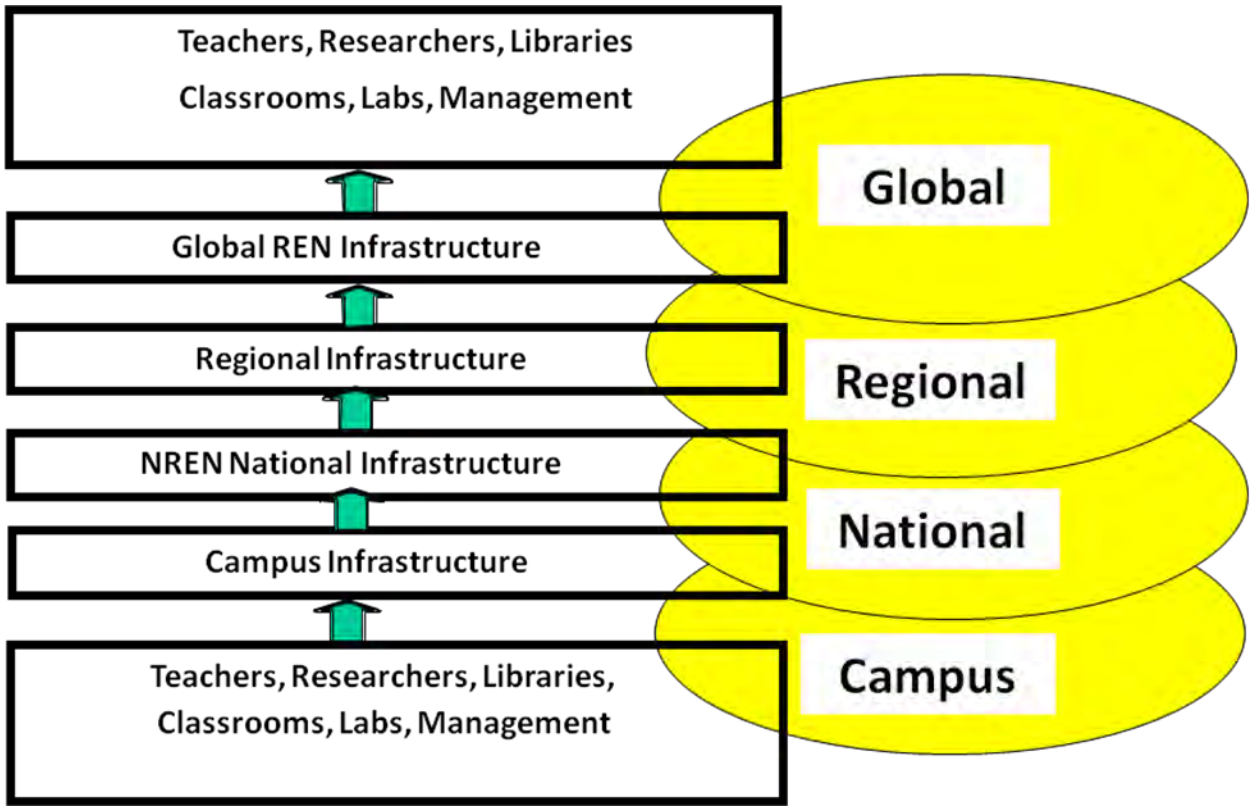
Figure 1 is an illustration of the multi-layered structure of the global research and education community.

NRENs fall into the following common models:

i. Bottom-up or Grassroots

These are NRENs that are initiated, owned, and funded by universities and research institutions (with government recognition, acceptance, and very often direct or indirect funding support). Examples of these are Internet2 (USA), the Tertiary Education Network (TENET)[17] of South Africa, and the Research and Education Network of Uganda (RENU)[18]. (It should be noted that while Internet2 is used as an example of an NREN because it covers one country, the semi-autonomy of the states in USA makes it a *de facto* RREN).

Figure 1: Layered Model of the Global Research and Education Community



Grass-roots NRENs have the benefit of organisational structures and processes that are quite close to the private sector, permitting the kind of rapid decision making and organisational agility that are in consonance with the nature of the sector they work in. They also respond to member needs because the members are the top policy body that sets up the Board and

[17] http://www.tenet.ac.za/
[18] www.renu.ac.ug

executive arms of the NREN. They will however find it harder, especially in the initial stages, to gain recognition and acceptance by governments, and they will always have to lobby hard where public sector funding is needed.

Grassroots NRENs can also face competition – which is not necessarily bad, but can be very challenging. In the USA, the National Lambda Rail (NLR)[19] is a competitor to Internet2, even if necessity requires them to work together in some instances. In South Africa, TENET is very well established as an NREN owned by the universities and research institutions, and running the most advanced NREN network in Africa. Government has however also set up the South Africa Research and Education Network (SANReN)[20], operated, through a formal agreement, by TENET. TENET uses this capacity to distribute the 10Gbps international connectivity they procured as indefeasible rights of use (IRUs)[21]. This functional collaboration has however not yet resolved the question of which of the two is the South African NREN.

ii. Top-down (1)

These are NRENs initiated and owned by government, for example the Ethiopia Education and Research Network (EthERNet)[22] and the Sudan Universities Information Network (SUIN)[23].

Top-down NRENs are subject to the typical environment of any government managed institution. These include slow and procedure bound processes that disable tactical decision making; lack of awareness of costs; not efficiency driven; and often not responsive to the needs of the institutions they serve.

They have an advantage of immediate recognition and acceptance by governments because they own them. They also have a possible advantage of easier access to funding – possible but not certain because this is not necessarily always the case, especially if the government puts the NREN low on the priority scale.

iii. Cooperation between government and universities

In this model, there is mutual recognition of the roles of both parties. SUIN, for example, is now moving to the state where government is happy to continue with funding support while devolving management and control to the universities. South Africa is also likely to end up in this state, this time with TENET accepting some involvement of government at the policy level while the government leaves management control in the hands of the universities. RENATER[24] in France benefits from full government funding but is managed independent of government.

[19] http://www.nlr.net/
[20] http://www.sanren.ac.za/
[21] IRUs grant to the purchaser specific rights for a specific period of time. In the case of data communication networks, this translates to a given amount of bandwidth that will be available for the sole use of the purchaser for the defined period. TENET purchased a 10Gbps IRU on SEACOM for a period of 20 years.
[22] www.ubuntunet.net/ethernet
[23] http://www.suin.edu.sd/
[24] http://www.renater.fr/

The cooperative model, if well handled, could produce the best of both worlds: availability of funding from government, ideally through the member institutions, and management and control by the universities through a Board and executive arrangement selected by members.

2.3 NREN Growth in Africa

The growth of NRENs in Africa started just over ten years ago, and was initially motivated by the high cost of bandwidth that has led to intellectual isolation of researchers and academics in Africa. At that time, typical bandwidth costs were as high as USD7,000 for a half-circuit Mbps per month via high latency VSAT circuits, translating to USD14,000 per Mbps per month, compared to less than USD50 for the same capacity in the USA and Europe. This was and continues to be one of the major development contradictions: that in countries where the per capita income is generally less than 4% of that in the developed countries, such an essential link to the knowledge society would cost 30,000% more.

Towards the end of 2008, data from TeleGeography's Wholesale Bandwidth Pricing Database showed that the median price of a 2Mbps circuit between London and Johannesburg was nearly US$15,000 – the same price that could lease 10Gbps between London and New York. While costs have dropped in some locations to US$300 and lower per full duplex Mbps per month (about 3% of what it was three years ago), costs remain well beyond what is typical in developed countries (of the order of US$20-30 for the same capacity), and countries like Zambia are still paying the old rates.

Cooperation in Africa that has led to the formation of NRENs was therefore initially definitively driven by the need for access to cheaper bandwidth. The earliest initiative was based on a research report and recommendations by the Bandwidth and IT Task Force (Band-ITs)[25], that was supported by the Carnegie Corporation of New York. This led to the establishment of the African Universities Bandwidth Consortium (AUBC). AUBC was supported by the Partnership for Higher Education in Africa, and was able to negotiate costs for participating institutions to less than 50% of the original VSAT prices. It was initially hosted by the African Virtual University, but has now moved on to the Nigerian ICT Forum as the demand in Eastern Africa dropped due to the arrival of highly competitive fibre in an organised REN environment.

During 2004/5 the 11th General Conference of the Association of African Universities (AAU), AAU was given a mandate to establish *a "Working Group on Information and Communication Technology (ICT) to guide the Association's support of the ICT capacity of its member institutions and, especially, the development and implementation of an action plan to set up a network of African higher education institutions to negotiate the acquisition of higher bandwidth at lower cost."* With funding for the IDRC, AAU commissioned a study to guide the implementation of

[25] Accessing More and Cheaper Bandwidth – A Report for the Partnership for Higher Education in Africa, 2003

the resolution. In their recommendation, the consultants, Tusubira and Mulira, specifically recommended that[26]:

> *"While the focus of this report relates mainly to the challenge of getting access to more bandwidth at a lower cost, the authors feel very strongly that this alone does not provide a sound platform for the role of the AAU. The role of the AAU must be seen within the broader context of using its unique positioning to enable the higher level benefits of a consortium approach to learning, research and community outreach, with the integrating ICT services and systems in institutions as an enabling layer. This particular function has been highlighted in the report as the long-term justification for the AAU initiative, bandwidth being just one facets of the many challenges".*

The Research and Education Networking Unit of the AAU[27], which has played an increasingly key role in promoting REN activities and awareness in Africa, was subsequently established.

By 2006, the only NRENs that were operational in sub-Saharan Africa, in the sense that they were consolidating and delivering local and international connectivity to their members, were TENET in South Africa and, at the starting stage, KENET in Kenya. Librarians in Sudan and Malawi had also set up infrastructure for sharing resources, though these had not yet evolved to become NRENs.

Three factors can be said to have led to the creation of the UbuntuNet Alliance, the pioneer RREN in Africa[28]. First were the studies conducted during the early to mid-2000s, like the SARUA Fibre Study, that started bringing to light the substantial reservoir of unutilised optical fibre capacity in Africa, owned especially by utility companies. Second was a new wave of liberalisation as monopoly and other limited competition provisions stipulated during the first wave of liberalisation in the late nineties expired, creating opportunity for such fibre to come on the market. Third, and especially significant, were the plans for the first east coast submarine cable, known as the East African Submarine System, or EASSy. Driven by internal need, availability of the opportunities cited, and catalysed by external suggestions[29], embryonic and developed NRENs in five countries came together to initiate the development of an African regional REN[30], leading to the birth of the UbuntuNet Alliance for Research and Education Networking (often referred to as the UbuntuNet Alliance or simply the Alliance).

The UbuntuNet Alliance has defined its strategic priorities within the frame of their programme called "Consolidating Research and Education Networking in Africa (CORENA)". The *overall goal* of this project is to enable an environment in which African Education and Research Institutions

[26] Tusubira, F.F., and Mulira, N., "The Proposed Role of the AAU in Supporting Member and Associated Institutions in Exploiting the Benefits of Networking", Report to the AAU, Dec 2005.

[27] http://www.aau.org/?q=content/research-and-education-networking-unit

[28] Tusubira, F.F., "Creating the human and infrastructure networks research and education networks in Africa", Proc TERENA Networking Conference, 2009, Malaga

[29] Bjorn Perhson of KTH and Steve Song, then of Connectivity Africa, were some of the key external parties that encouraged the setting up of a formal organisation.

[30] The pioneers were Victor Kyalo of KENET, Kenya; Margaret Ngwira of MAREN, Malawi; Duncan Martin of TENET, South Africa; Americo Muchanga of MoRENet, Mozambique; Albert Nsengiyumva of RwEdNet, Rwanda. The author was part of the initial discussions, but could not participate formally: there was no formal NREN in Uganda at the time.

can exploit their full potential in contributing to national and international human development; and in increasing their countries' contribution to, and share in intellectual property output, through effective national, regional and international collaboration. The *principle objective* is enabling the integration of African universities and research centres into the global research and education community through provision of intra-African connectivity and enabling access to sufficient and affordable international internet bandwidth. The hypothesis is that[31]:

> *"Improved and affordable connectivity will enable African researchers to produce proportionate intellectual output and generate a proportionate amount of intellectual property goods"*

Over the last four years, there has been a spurt of growth of NRENs, most of them still at the organisational level and not yet delivering services. Figure 2 shows the existing NRENs in the Alliance, and the RRENs of Africa, by July 2011.

Figure 2: Growth of NRENs in Africa

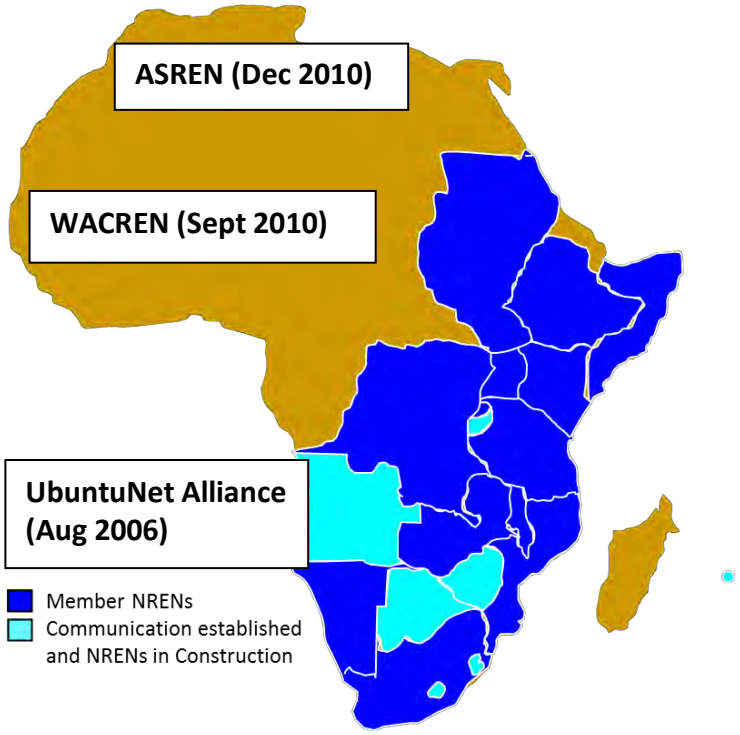
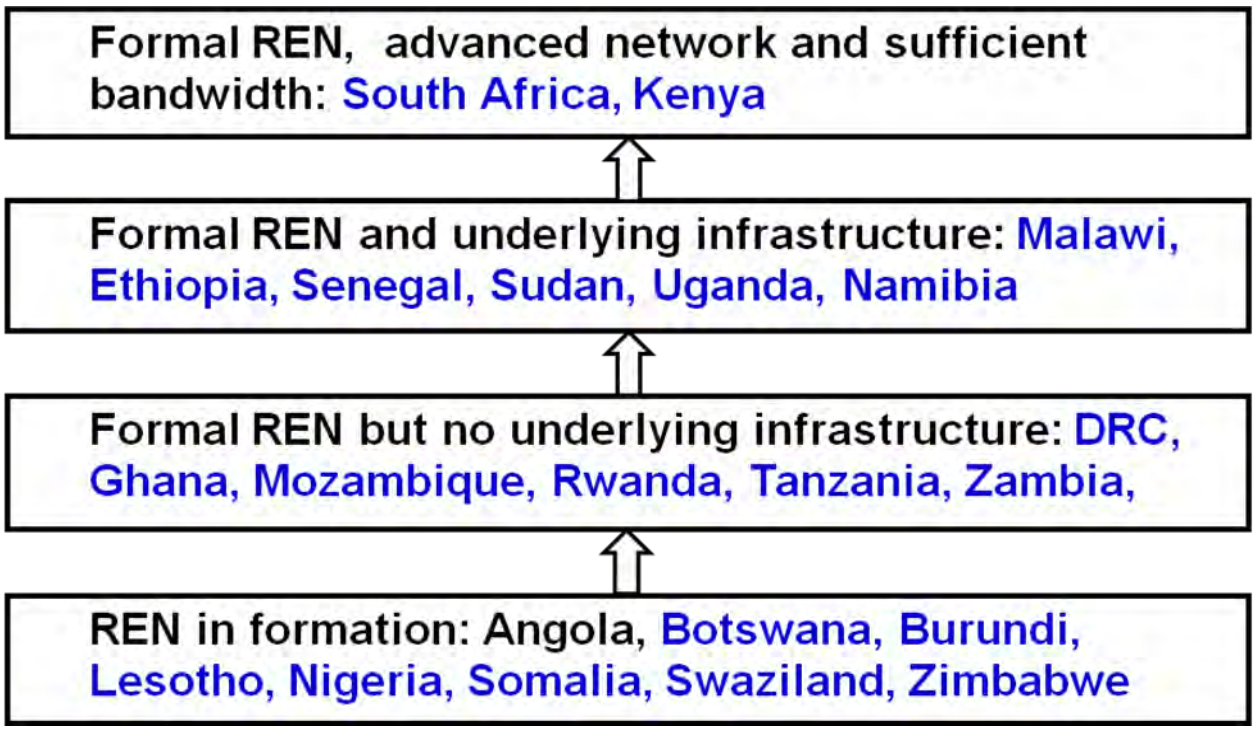


Figure 3 is a descriptive presentation of the current operational status of the NRENs in Africa, showing that many of them still have a long way to go.

[31] Consolidating Research and Education Networking in Africa, CORENA ; 2008. UbuntuNet Alliance internal document

Figure 3: Operational Status of NRENs in sub-Saharan Africa



2.4 Examples of NRENs from Africa and Around the World

This section gives a selection of examples that provide learning points for NREN stakeholders in Africa. The examples used include Internet2, CLARA, UbuntuNet Alliance, KENET, TENET, and XNet.

2.4.1 Internet2[32], USA

Internet2 is organized as a not-for-profit and takes pride in being community led and member focused. Internet2's core mission is *"to ensure that scholars and researchers have access to the advanced networks, tools and support required for the next generation of collaborative discovery and innovation and for effectively preparing the next generation of innovators, our students"*[33]. Started in 1996 with 34 universities, Internet2 now has 372 members and 131 sponsored education group participants. Members include U.S. universities, corporations, government research agencies, and not-for-profit networking organizations representing over 50 countries. Internet2 membership is by institution and has been restructured into four levels based on the Carnegie Classification assignment for Higher Education members, operating budgets for Affiliate members and revenues for Industry members. These levels determine membership dues and fees.

[32] See Blog Essay by Maria Beebe and Internet2 url - http://www.internet2.edu/
[33] ibid

To bring more innovators to the table, the Internet2 developed a K20 Initiative to connect university members to the broader education community through a process called Sponsored Education Group Participants. The result is connection to the Internet2 backbone network of 66,000 Community Anchor Institutions (CAI) in 38 U.S. states. CAIs are community-based organizations that include K-12 schools, libraries, community colleges, health centers, hospitals and public safety organizations. The plan is to extend the network to 200,000 CAI through a Broadband Technology Opportunities Program (BTOP) grant. The $62.5 million grant will upgrade the Internet2 Network to an 8.8 Terabit per second national network. The infrastructure will serve not only the Internet2 members but also 200,000 CAIs. Since CAIS are not Internet2's traditional research university members, a different network, U.S. Community Anchor Network (CAN) was established to bring together the diverse voices of CAIs, with start-up costs provided by Internet2 and other partners. Thus, the physical infrastructure will be shared by Internet2 and U.S. CAN; however, Internet2 will focus on network R&D needs of its members while U.S. CAN will tailor its programs to the various community anchor sectors.

Opening Internet2 membership to industry partners has reciprocal benefits. Benefits from industry include significant contributions in support of the development and deployment of advanced, Internet applications and services, including donations of equipment, cash, software, personnel, consulting, and services. By serving on Internet2's Board of Trustees and its advisory councils, industry members make available valuable input and strategic guidance on advanced networking in research and education. Benefits to industry partners include ability to interact with current and prospective customers, showcase products and services, acquire market and user intelligence, tap and recruit university talent, and discover new market opportunities, among other things.

The governance structure is member-led and member-focused. The Board of Trustees is inclusive, consisting of representatives from members, including university presidents and Chief Information Oficers, and leaders from industry and research agencies. The Board offers leadership, strategic direction, and oversight. The size and diversity of its membership requires advisory councils, again coming from its membership, for its many services: Applications and Middleware; Architecture and Operations; External Relations; and Research. These Advisory Councils guide strategic planning and implementation, help set organizational priorities, and ensure that Internet2 continues to serve the needs of the research and education community members.

Members are engaged and opportunities for membership engagement abound through a variety of Working Group activities, such as development efforts in network infrastructure, network performance, middleware, applications, and security, and discovery, research, and collaboration in discipline areas, such as the arts and humanities, health sciences, and sciences and engineering. Members also have access to a comprehensive menu of services, tools, capacity building, and R&D. Examples include:

i. A systems approach to high performance networking that provides a wide range of integrated services, from dark fiber to production IP and optical networking, to middleware and advanced applications. The network is designed to deliver next-

generation production services and serves as a development platform for new networking ideas and protocols. The Internet2 Network is scalable to meet bandwidth-intensive requirements of collaborative applications, distributed research experiments, grid-based data analysis and social networking. The network will be upgraded with the BTOP grant mentioned above.

ii. The Internet2 Commons, a suite of tools that integrate presence, instant messaging, chat, voice, video, data and application sharing. It now offers cloud-based interoperable video services from tele-presence to videoconferencing to desktop and mobile tools.

iii. The pS-Performance Toolkit, which includes a pre-configured suite of network performance tools for collection, storage and analysis of network performance data.

iv. InCommon, a framework for inter-institutional authentication and authorization to enable secure access of protected online network services and resources.

v. The U.S. Higher Education Root (USHER), which acts as a public key infrastructure (PKI) solution for the higher education community for applications and services that require encryption or true digital signature technologies.

Finally Internet2 workshops provide participants with the opportunity to learn about and experiment with advanced networking technologies. Workshop topics include: Hot Topics in Identity Management and Federated Identity Management; Network Performance; IPv6; Campus Architecture and Middleware Planning; Digital Video Transport Systems; Performing Arts and Master Class production to advance the frontiers of high-performance networking in service of research and education.

The success factors of Internet2, all discussed above, include:

i. The provision of a critical suite of services and opportunities to members as highlighted above;

ii. The close collaboration with industry to the extent of creating a class of membership for them and getting them fully involved;

iii. Members ownership and direction;

iv. The many opportunities provided through which human networks are developed and strengthened.

Internet2 is one of two networks serving the USA on a regional basis, the other one being the National Lambda Rail. This element of competition does create challenges but is also a driver for ensuring efficiency and creativity in delivering value to members.

2.4.2 Red CLARA – the South American Regional REN[34]

CLARA is the RREN of South America. The impetus to form the regional network was provided by funding from the European Union Commission (EUC) under the ALICE[35] project, with implementation through DANTE, the organisation that manages the European RREN, GÉANT.

[34] www.redclara.net

[35] http://global.dante.net/server.php?show=nav.1413&PHPSESSID=2c1a3aade08678c7074f46328f7b7b76

The bigger NRENs then existing in South America, specifically the Brazil and Argentina NRENs, have played a major role in enabling the weaker NRENs to get to the level of participation and actually start benefitting from the services, by both providing expert support and assuming a disproportionately large financial burden.

CLARA faced challenges of sustainability at the end of ALICE because sustainability was not factored into the planning by the member countries early enough. When European support ended, CLARA faced major financial and operational crises that almost brought it to a standstill. The start of the second phase, ALICE2, diverted this challenge that has nevertheless been a learning point for CLARA and other NRENs (like the UbuntuNet Alliance). CLARA is gradually now moving to get all South American countries on board and get to the level of a world class RREN.

Success factors include:

i. The willingness of established and financially able NRENs to meet costs above their direct benefits;
ii. There has also been a very strong focus on engineering design, creating a very strong engineering team that was able to keep CLARA functioning despite the transitional challenges.

2.4.3 The UbuntuNet Alliance for Research and Education Networking[36]

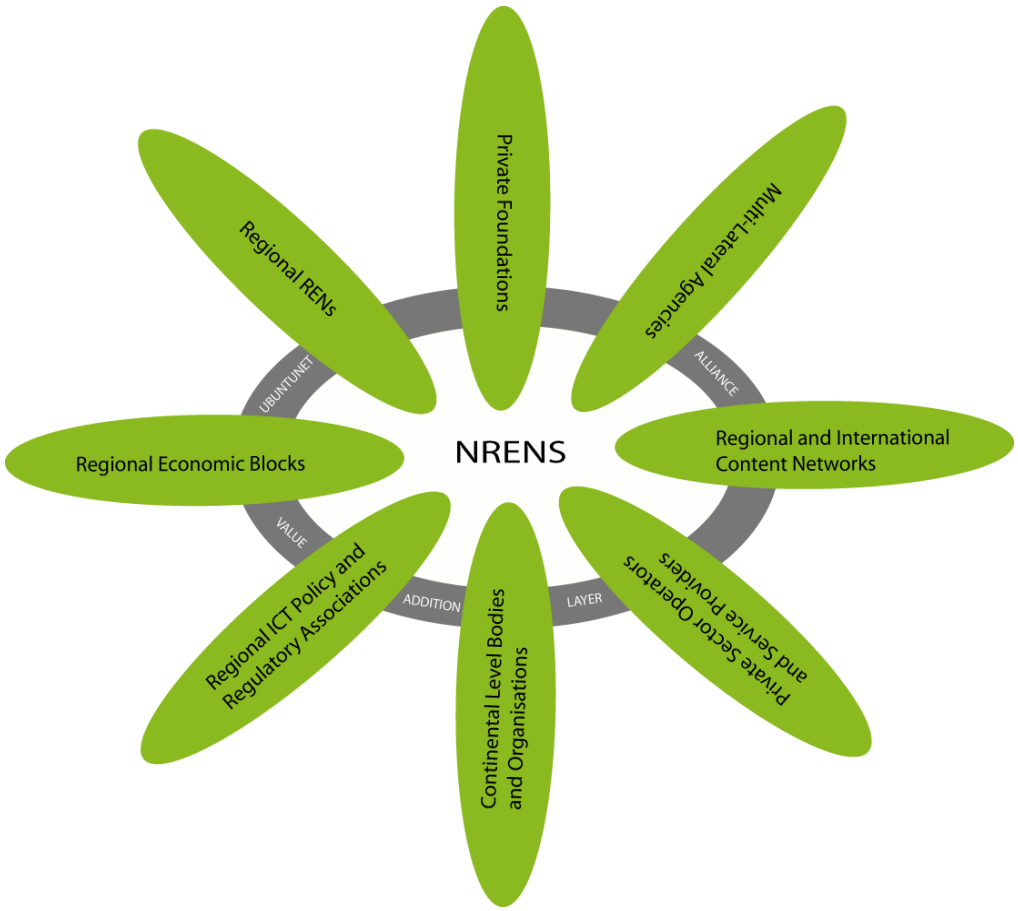
The history of the UbuntuNet Alliance has been captured in the discussion about the growth of NRENs in Africa.

UbuntuNet has put very strong emphasis on creating awareness and enabling the start and growth of NRENs in its membership region, creating value at each stage of their development, and offering them network services as well as the opportunity to collaborate. The other emphasis has been on stakeholder identification and engagement, and focusing on roles that provide value for members while not violating their autonomy. This is illustrated in the UbuntuNet Alliance Stakeholder Map in Figure 4.

The Alliance was able to get initial support from the International Development Research Centre[37] of Canada based first on environmental research to identify opportunities and barriers relating to the growth of NRENs, and to formulate approaches to addressing them. This was followed by support related to researching the impact of increased and cheaper connectivity on intellectual property output of African universities.

[36] www.ubuntunet.net
[37] http://web.idrc.ca/en/ev-1-201-1-DO_TOPIC.html

Figure 4: UbuntuNet Alliance Stakeholders Map showing the Value Addition Layer of the Alliance



The Alliance focused on an operational presence from the start, establishing a point of presence (POP) using a router (donated by Cisco) in London connected to the European GÉANT network, and through that to the rest of the world. The other POP is in Johannesburg. The total connected capacity through the UbuntuNet router in London has increased from less than 1Gbps when it was set up to about 12Gbps now. The interconnection with GEANT has also been increased from an initial 1Gbps to 20Gbps now, inclusive of a 10Gbps point to point route.

During May 2011, a contract for the implementation of a regional network for the Alliance membership region, with a total value of €14.8million, was signed between EUC and DANTE, with the Alliance as the main implementing beneficiary. This is aimed at establishing regional connectivity among the Alliance member NRENs. The Alliance, through the members, will meet 20% of the total cost.

The Alliance has been able to establish a very strong human network on which the NRENs draw for support and guidance in their growth and operations. This is easily the strongest point. Other success factors to date include:

i. Sustaining members interest through capacity building and support, creating value beyond bandwidth;

ii. Planning for sustainability as part of the strategic plan priorities, and insisting that members pay their contributions without fail, key to building sustainability.

iii. Established an operational POP from the start (supported by donations);

iv. Strong stakeholder engagement that has earned the Alliance international recognition;

v. Active support for the establishment of the West and Central African Regional Network, WACREN;

vi. Starting off with a Board and CEO who were internationally recognised pioneers;

vii. Focus on creating trust from the start;

viii. Running a thin delocalised organisation with outsourced operations;

ix. Support from the stronger members, much like South America. TENET has provided the core of this support.

2.4.4 KENET, Kenya NREN[38]

The Kenya Education Network, KENET, is a member founded organisation that, from the beginning, actively involved the regulator, but without ceding control to them. From the beginning KENET has enjoyed a lot of government goodwill and support. It received a start-off grant of US$300,000 through government under the Leland Initiative to connect universities. This enabled operations in a situation where there was very limited connectivity within Kenya.

Until recently, KENET was run by a CEO and support staff whose time was donated by the member institutions, saving KENET from the challenge of human resource cost during the start-up and stabilisation phases. Office space is still provided by Nairobi University.

KENET exists in an environment where government has taken the importance of ICT from the level of merely expressing commitment and importance to actualisation through government funded interventions that target all sectors. The Kenya ICT Board is charged with the responsibility of cross-cutting ICT strategy and interventions. Both the Ministry responsible for ICT and the Ministry responsible for science and technology (under which support to KENET falls) have for a long time had permanent secretaries who appreciate the importance of science and technology to national development, and the role of a national NREN in this. These have been key champions for KENET and, in addition to the owner institutions and KENET leadership, have actively promoted KENET.

[38] www.kenet.or.ke

KENET received a donation from government of an STM-4 international bandwidth on the TEAMs marine cable, and a US$20million grant to roll out high capacity connectivity to universities in Kenya and to reinforce external connectivity. From a total distributed capacity of less than 20Mbps for all universities two years ago, KENET has increased to 5xSTM-1 of external connectivity, a very improved internal network, and a modern data centre. Prices for member institutions have gone down from US$4,800 to US$300 per Mbps per month in two years.

KENET's key success factors have included:

i. Starting off with very low operational overheads because of seconded staff and office space;
ii. Very strong support from government and the regulator, all within an environment where the importance of ICT has risen to be one of the major development strategies. There is an integrated government strategy for ICT that recognizes the role of the NREN;
iii. A start-up grant to establish operations and connectivity;
iv. Effective and dedicated CEOs who have seen KENET through the start-up and growth phases;
v. Coastal location of Kenya, with easy access to marine fibre without intervening cross-border challenges;
vi. A large member base that distributes operating overheads

2.4.5 TENET, South Africa[39]

Like most African NRENs at the time, TENET, easily the oldest operational NREN in South Africa, was founded about 12 years ago by the member universities that wanted to address the challenge of bandwidth cost. They received a start-up grant of $1million from the Andrew W. Mellon Foundation. The same Foundation later funded a grant under the title "Fostering Research and Education Networking in Africa", upon which many of the start-up NRENs in sub-Saharan Africa as well as the Alliance have called to enable their start-up activities.

TENET started with an agency model, getting price reductions through aggregation and negotiation with service providers. They underwent a major change when they secured a $20million bank loan to purchase 10Gbps 20 year IRU on SEACOM. This was based on an education discount that SEACOM was willing to offer to NRENs. The way TENET mobilised funding for the 20 year IRU is noteworthy. At that time, TENET's net assets were barely 5% of what would have been required to secure the $20million loan. TENET convinced the member institutions to guarantee repayment of the loan, each committing to a specific amount related to a guranteed bandwidth capacity when the fiber went live, along with a payment schedule for the portion guaranteed.

With the need to distribute this bandwidth, TENET now faced the challenge of getting access to internal capacity at prices that would not negate the excellent prices they were getting from SEACOM. TENET could not do this at the time because they had only an Electronic

[39] www.tenet.ac.za

Communications Services (ECS) license that did not permit them to own or operate their own transmission infrastructure. By fortunate coincidence, the vibrant private sector operators took the matter of exclusion from Electronic Communication Network Service (ECNS) licensing, under which a company could own and operate infrastructure, to court. The court ruled against the government and the regulator, and more than 300 ECS licensees were able to acquired ECNS licenses overnight. TENET was an unplanned beneficiary of this, moving from the agency model to acquiring internal capacity for distribution.

About the same time, the government of South Africa decided to establish the South Africa Research and Education Network, SANREN, through which a 10 Gbps backbone would be rolled out to universities and research institutions. The project, despite initial challenges, rolled out quite fast and the first rings were completed during 2010. Figure 5 shows the SANREN backbone status by November 2011. TENET was engaged by SANREN to operate this capacity. This capacity, combined with TENET's external capacity, has helped end user prices for combined international and national bandwidth to drop to about $130 per Mbps per month, down from $1,200 two years ago. After the bank loan is paid off, the price of $130 will drop further to a level comparable to current prices in Europe and North America.

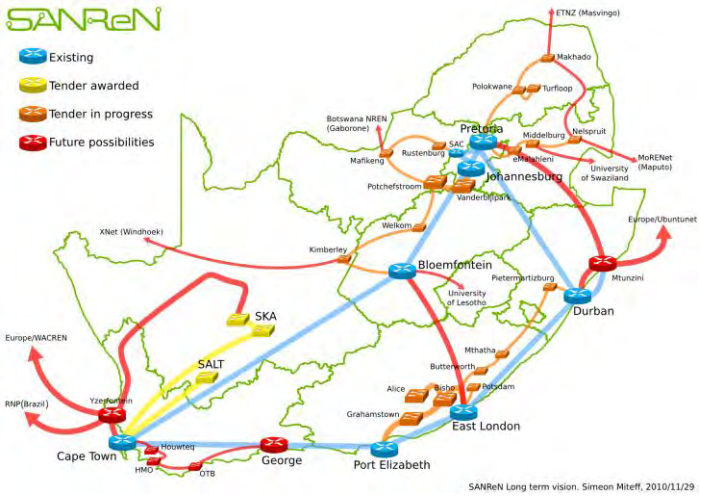
The creation of SANREN has led to organisational tensions that both SANREN and TENET are working to find a solution to. At the operational level, all institutions have however benefited.

TENET hosts Google caches in South Africa, and that has boosted their negotiating power with commercial providers.

Key success factors for TENET include:

i. A government that has committed a lot of resources to education and research, creating a general supportive environment, despite some of the tensions;
ii. A very effective CEO who also have an outward focus and has committed a lot to regional networking. This will, in the medium to long term, benefit both South Africa and the region;
iii. A start-up grant;
iv. Thin organisation. Even in the current phase, TENET uses a lot of outsourcing;
v. A strong membership base of well established universities;
vi. A vibrant and expert private sector that makes outsourcing viable;
vii. A high volume of traffic and a very large network, giving it a very strong negotiating position with the private sector and service providers;
viii. The court decision that cleared the way to full operations

Figure 5: SANREN Backbone - status and planned expansion, November 2010



2.4.6 XNet, Namibia

XNet was formed as a partnership between SchoolNet Namibia and Telecom in 2003 as a vehicle to provide affordable bandwidth connectivity to a variety of social sectors e.g. agriculture, health, SME, etc beginning with the Education Sector. While Xnet itself did not own an ISP or any part of the network and did not possess contract or service agreements with Telecom/service providers, SchoolNet Namibia had its own Internet Service Provider (ISP). Schools could connect via a dial-up modem or through wireless links via high masts owned by SchoolNet Namibia or Telecom Namibia. Subsidized dial-up rates were negotiated for poorer schools[40].

Additionally, SchoolNet Namibia played a pioneering role in experimenting with low-cost connectivity alternatives to connect rural schools to the Internet one of which was a pilot involving a narrow-band radio network connected via a series of forty five towers bringing coverage to about 900 schools[41]. To be cost-effective, at least ten schools needed to lie within a 20km radius of a single tower. The cost could then be amortized over a large number of schools such that that the cost, over ten years, would be an affordable US$18 a month - a fraction of the US$400 monthly costs of running satellite feeds[42]

Through the Xnet structure, SchoolNet was able to provide affordable connectivity to more than 1000 schools throughout Namibia. Telecom Namibia is the main provider of the access network – between institutions and national backbone and is also the major provider with

[40] http://wikieducator.org/The_Case_of_SchoolNet_Namibia/Operations/Activities/Connectivity
[41] http://www.schoolnetafrica.org/fileadmin/resources/School_Networking_Initiatives.pdf
[42] http://wikieducator.org/The_Case_of_SchoolNet_Namibia/Operations/Activities/Connectivity

access to international gateway in Namibia[43]. Connectivity via Telecom Namibia comes with guaranteed "fixed access rates for all schools, irrespective of how they connect[44.]

Key factors that have made this collaboration a success:

i. The emphasis on open source software and Creative Commons content is especially central to its success. Working with open source has stimulated SchoolNet to explore the real costs of ownership of ICTs in schools and has ensured that the technical solutions SchoolNet Namibia provides are affordable to schools, and are therefore viable in the long term[45].
ii. Strong relationships with stakeholders are another key factor. SchoolNet Namibia operates in line with Namibia's ICT policy for education and has built a strong relationship with the Ministry of Education. So much so that the Ministry has begun to take ownership of the SchoolNet implementation mechanisms. Similarly, a symbiotic relationship with Telecom Namibia, and lengthy negotiations, resulted in discounted Internet connectivity rates for schools[46].

Another key partnership has been with Microsoft. Microsoft is not only on the board of Xnet but is also working to establish a strategic partnership with Xnet for the provision of discounted internet connectivity to Community Information Centers (CIC).

During late 2010, Xnet became the first member of the Alliance that evolved from a Schoolnet. They still face the challenges of full acceptance by the higher institutions, especially the University of Namibia – the largest public university. This is a challenge they need to address before Xnet can become a fully effective NREN.

3 OPPORTUNITIES AND CHALLENGES[47]

3.1 Opportunities

i. A growing awareness among African countries of the importance of increased investment in higher education as a key pillar for national development

Various studies have demonstrated the direct link between investment in higher education and national development. The World Bank is particularly working to disseminate this information among developing countries, a few of which are responding through increased direct

[43]http://www.powershow.com/view/5690-ZTdhN/Telecom_Namibia_is_main_provider_for_the_access_network_b_flash_ppt_presentation
[44] Empowering Youth and Connecting Schools: Lessons from the SchoolNet Namibia Approach , INASP infobrief 2: School Networking: February 2004
[45] http://www2.unescobkk.org/elib/publications/111/Schoolnet_LLVol.3.pdf
[46] http://www2.unescobkk.org/elib/publications/111/Schoolnet_LLVol.3.pdf
[47] Tusubira, F.F., "Creating the human and infrastructure networks research and education networks in Africa", Proc TERENA Networking Conference, 2009, Malaga

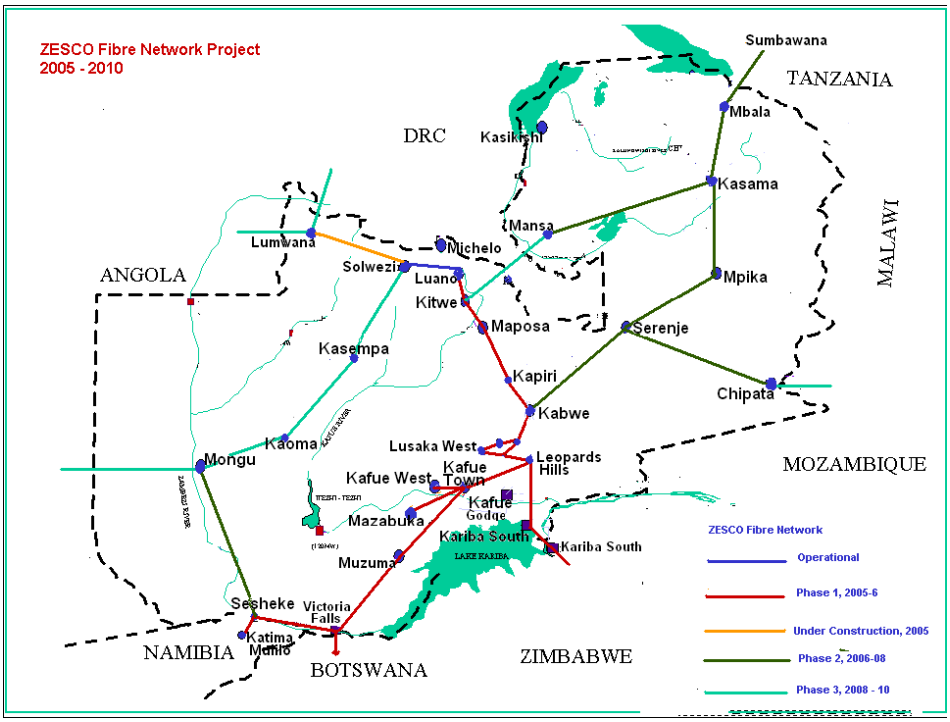
investment or the provision of student loans. The need for skills is also linked to the efforts by many countries to attract foreign direct investment in competition with other investment, both African and non-African. Better resourced universities are able to provide more realistic funding for information and communication technology, creating environments in which national, regional, and international research and education linkages grow and thrive.

ii. Increasing liberalisation of the telecommunications sector

As will be discussed later, policy and regulation remain a major challenge. The general trend has nevertheless been an increasing relaxation of regulation that has enabled entities that have fibre capacity to put it on the market. For a long time power and railway companies particularly have held fibre capacity as part of their signalling and control systems, and are now bringing this hitherto idle fibre on the market, reducing local access costs. Figure 6 illustrates, as an example, the existing and planned fibre of ZESCO, the Zambia power company. This kind of situation exists in all countries in the membership region that have well-developed power and railway sectors. Figure 7 shows the evolving map of global and intra-African fibre that is maintained and updated by the UbuntuNet Alliance[48].

Sector liberalisation has also given opportunity to NRENs to set up, own and operate private networks, including international gateways.

Figure 6: Existing and planned fibre of the Zambian power company, ZESCO



[48] www.ubuntunet.net. This map also draws on data from www.manypossibilities.net through the kind permission of Steve Song who maintains the map of fibre to Africa.

iii. Investment into national fibre backbones

The first wave of liberalisation in the nineties saw most governments pull entirely out of the development of telecommunications infrastructure. It was realised after some years that while there was heavy investment in mobile telephony (motivated by demonstrated rapid returns on investment), there was very limited investment in high capacity data backbones, the workhorses of the internet. Plans for e-enabled services (education, health, commerce, governance, etc) on which many governments had embarked could not move ahead. Over the last three years, many governments (for example Uganda, Kenya, Rwanda, Tanzania) have moved to establish extensive national data backbones. Access for the education and research sector has been made a priority in most cases. Other countries like Ethiopia moved even earlier into the implementation of national backbones as public projects. All these countries have received support from bilateral and/or multi-lateral development agencies: data backbones are now considered as key development infrastructure.

In Uganda, the National Fibre Backbone (Figure 8: The Uganda National Fibre Backbone) was funded by a development loan from the government of China through Exxim Bank. After the National Fibre Backbone Project was signed off, the Minister of ICT pledged the availability of a dark fibre pair to the Research and Education Network of Uganda (RENU). With most of the fibre completed, RENU has reached a formal agreement in principle with the National Information Technology Agency (which manages the backbone) for access to the fibre, with the understanding that the capacity made available will be accessed by all education institutions at all levels. While meeting the backbone needs of the universities will be comparatively easy, there will be challenges in serving the rest of the education institutions. It is more than likely that this will be addressed through SchoolNet Uganda, which will manage user groups and needs while RENU gives the required support in ensuring availability of connectivity.

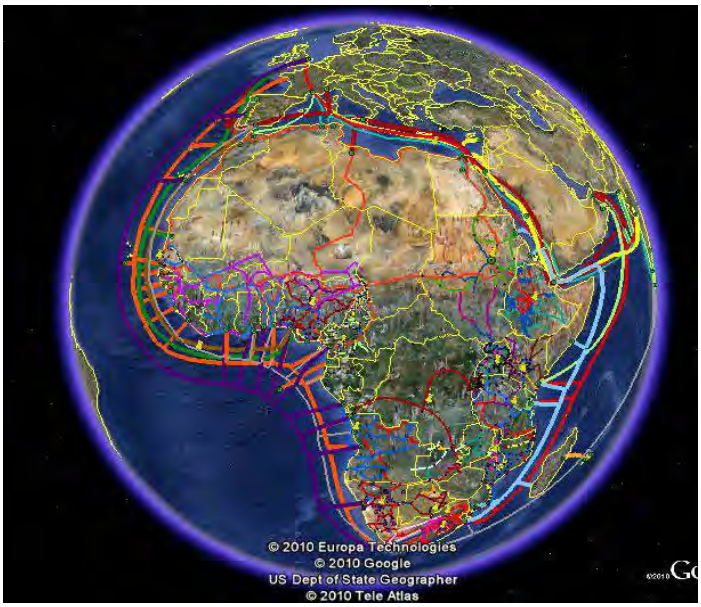
Uganda also has a good illustration of a PPP initiative. The Internet Educational Equal Access Foundation (IEEAF), a non-profit, worked with USAID to provide equipment that has been used to light up Phase 1 of the RENU backbone at 10Gbps. The fibre used belongs to Uganda Telecom, a commercial service provider through a negotiation by the Global Medical Research Exchange, a for profit company based in the USA. Through the agreement, RENU has been granted access to the UTL dark fibre wherever it exists at no cost. RENU is has just started the phase of implementing their data backbone, so there is no visible impact yet on cost and volume of access.

The example of Kenya has been discussed under KENET (see page 17). It should be noted that increased connectivity also requires human resource with the capacity to ensure availability and security of the network. KENET has worked very closely with the Network Start-up Resource Center (NSRC) based at the University of Oregon, and also twinned with the German NREN DFN in order to build advanced capacity among its team.

South Africa's example stands as another illustration of government support to NRENs (see page 18). The biggest challenges in South Africa have been establishing last-mile connectivity

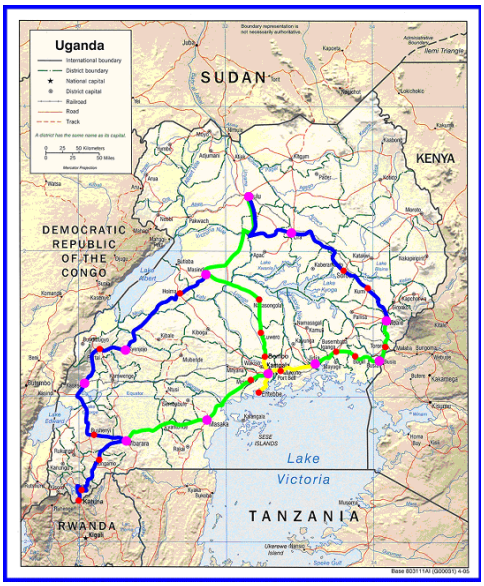
to more remote campuses at reasonable bandwidth and the ability of many of the universities to absorb such bandwidth. Fibre has been used as the standard approach wherever possible. It should be noted that the availability of very high bandwidth at low cost has also positioned the Southern Africa region to be competitive in the location of the Square Kilometre Array.[49] This success would be a major boost to the already high credibility of South Africa as a country capable of hosting high end research initiatives and would lead to increased inflow of research funding and opportunities for universitiesNothing demonstrates the insufficiency of bandwidth to external institutions more than a research linkage requiring the exchange of large files. This is especially true of the increasing linkages relating to medicine, physics, climatology, and other data-intensive areas of research. The external institutions have become key advocates for their governments and foundations to support improved research and education networking connectivity to and within Africa.

Figure 7: Map of evolving intra-African and external fibre to Africa



[49] http://www.ska.ac.za/

Figure 8: The Uganda National Fibre Backbone



iv. Increasing research linkages between African and non-African universities

A specific current example is four leading schools of medicine in the USA (John Hopkins, University of Washington, University of California San Francisco, University of Pennsylvania) establishing linkages with four leading schools of medicine in Africa (Makerere University, Muhimbili University of Health and Allied Sciences, University of Botswana, University of Nairobi) in a programme to train leaders in global health. These have identified sufficiency of connectivity as a key challenge to be addressed from the outset.

v. The number of high capacity marine optical fibres planned to land on the African coast starting 2009.

For more than fifteen years, there has always been one major plan or another to bring increased connectivity to Africa. Most of these failed to deliver results, to the extent that most people both within and outside Africa became sceptical about the success of current efforts. As can be seen in Figure 7 and in more detail with numbers published by Steve Song[50], fibre to Africa is now an accepted reality with multiple competing fibres landing on African coast as investors wake up to the potential of the continent. The relative thicknesses of the lines show the relative capacity.

SEACOM, TEAMS and EASSy have been completed, and WACS is close to completion. SEACOM, EASSy, TEAMS and WACS capacities are 1.28Tbps, 640Gbps, 40Gbps, and 3.84Tbps respectively. For the first time, there is real capacity for users, including NRENs, available in a competitive environment and creating the opportunity for access equality.

[50] Thanks to Steve Song. http://www.manypossibilities.net

vi. Increased development partner support for NREN activities in Africa

There has been a wave of support for the nascent African NRENs and RRENs since 2007. IDRC opened the way, with support to the formative stages in both Eastern, Southern, and Western Africa.

In Somalia, SomaliREN is getting support from Sweden. The World Bank is supporting (or planning to support) through the national governments NRENs in Kenya, Mozambique, Malawi and Tanzania. In Uganda, equipment and services close to USD 700,000 have been deployed to light up the first phase of the RENU backbone to provide 10Gbps internal connectivity. This was through USAID and IEEAF along with other private sector partnerships. In ZAMBIA, a NUFFIC intervention of €2.25m to support NREN infrastructure and capacity development is starting. The EUC support for the Alliance through DANTE has already been discussed.

vii. Demands by Internet Aware Students

The emergence of more public universities and private universities has created choice for students who, being internet-aware, are demanding a modern learning environment. It has become a question of survival for universities to provide this, creating an opportunity for NRENs to show their value.

3.2 Challenges

i. Shortage of skilled human resource

One of the biggest challenges faced by African institutions and NRENs is the dearth of people who are technically competent to design, operate, and maintain advanced data communication networks. The scarcity is compounded by competition with a rapidly growing private sector able to offer much better terms. The shortage is largely due to curricula in training institutions that supply human resource not matched to needs, taught by lecturers who do not yet understand the real needs of the sector. This has to be addressed through guidance to institutions about curricula, sharing expertise among NRENs, and creating opportunities for attachments and secondments. Institutions should also be encouraged to fully exploit the unlimited number of innovative bright students who want to learn, to experiment, and push out technology frontiers: there will always be a ready supply of these.

ii. Limited understanding of the multiple roles of research and education networks.

A successful NREN has got to achieve a fine balance between providing and assuring availability of sufficient and affordable connectivity – the entry point for African NRENs; enabling and promoting content networks; and researching into advanced infrastructure. It must also understand the distinction between providing services for a member group and competing with

the private sector. All this comes with experience and understanding best practices: the overwhelming majority of African NRENs are very young and do not yet have the necessary exposure. It is inevitable that fingers will be occasionally burnt. This challenge can be addressed through the dissemination of good practice and learning events.

iii. Disabling Policy and regulatory environments

As part of the Master Plan and Strategy development process, the UbuntuNet Alliance carried out a situational survey of the telecommunications sector policy and regulatory environments covering 22 countries in their membership region, with specific focus on impact on research and education networking activities. The following were found to be the key environmental barriers to access to broadband communication:

- Slow reforms in the communication sector
- Inadequate access to backbone infrastructure at affordable prices
- Inadequate policies and regulation with regards to ownership and access to essential infrastructure by universities and research institutions

iv. Slow sector reform

Policies and regulation that govern: access to spectrum; ownership of fiber infrastructure such as dark fiber; and interconnection and tariffs are often unfavourable, and also vary widely. Some governments in the region such as Kenya, South Africa, Tanzania and Uganda have made progress in reforming their telecommunications sector policy, legal and regulatory environments; and have also adopted technology neutral converged regulatory frameworks that promote access to broadband infrastructure. Others like Djibouti, Eritrea, Ethiopia and Swaziland still favour monopoly and restrictive regimes that hamper academic institutions' ownership and operation of broadband fibre and wireless networks.

v. Access to broadband Infrastructure

A critical aspect of high speed connectivity is ensuring that national and international fiber access is available and affordable. International access has now been addressed with competitive pricing being offered. Backhauls and internal distribution, as well as the last mile, remain major challenges.

vi. Ownership and access to essential facilities by academic and research institutions

The restriction on academic ownership and operation of network infrastructure is often due to the monopoly of networks by traditional incumbent operators that are regarded as sole owners of the network, including national gateways. In most countries, only the licensed operators and other public utility companies have the Rights of Way, and NRENs would have problems trying to establish their own networks if they so wished. In countries like Eritrea and Ethiopia the restrictions are extreme, with even the use of VSAT and its operation by academic institutions prohibited. In most of the countries NRENs can only purchase fiber capacity from existing

licensed providers. This denies them the option to consider ownership models that might be more cost effective or to build networks for special research purposes.

vii. Seeking individual advantage by member NRENs

It is a natural human trait to seek individual advantage, and group success relies on the ability of the individual to overcome this natural tendency. Africa has been starved of bandwidth for a long time. Suddenly, institutions and NRENs that have been paying USD 7,000 per full duplex Mbps per month see that they can get it at less than 10% of this price, creating a disorderly scramble that disorganises the group interest: with cooperative effort and negotiation, this could go to less than 5% for the group.

viii. Competition from and cherry picking by service providers.

This comes from the expected predatory tendency of the suppliers. In any NREN, there are institutions that are the largest and most affluent. They take the largest chunk of bandwidth. A regional REN like UbuntuNet is similarly composed. It is very tempting for the supplier, especially if there is a positioning among consumers for individual advantage, to enter direct agreement with these at concessionary terms. This weakens the group, making it more easily vulnerable to exploitation. The only solution to this is for the stronger institutions to appreciate that it is actually in their interest to work as part of the group, providing the necessary backbone during negotiations.

ix. Weak Financial Base

Where there are no tangible services being offered, it is difficult for member institutions that are themselves cash-strapped to contribute to a start-up organisation. This challenge can only be addressed by moving rapidly, necessarily with development partner support, to offer tangible services that are seen to reduce the costs of members and therefore provide incentive for payment of membership and agency fees. For African NRENs, the only commodity that can achieve this in the short to medium term is much cheaper bandwidth.

x. Generally poor campus networks and limited PCs for users.

The base of any NREN is the campus network, and the access that end users have to computing devices. Most institutions in Africa still have very rudimentary networks, and this weakens the NRENs. This calls for technical and funding support to institutions to enable them establish modern data networks along with sufficient PCs or similar devices for students and staff.

4 RECOMMENDATIONS

4.1 Recommendations to Governments

Ubiquity and effectiveness of all ICT related initiatives requires a minimum level of connectedness. For the managers and policy makers in government, this is likely to be through a dedicated government network, possibly provisioned by the private sector, while for all levels of education institutions, this should be the NREN. In addition to the in-country networks, international connectivity is needed for all users to permit dissemination of internal output and provide access to external resources.

i. Governments must recognise that the levels of funding of education that are now typical are no where near sufficient to set up the required connectivity and to sustain bandwidth costs. Connectivity for educational institutions should therefore be placed among the national social development priorities so that these institutions can benefit from directly funded infrastucture and direct donations, and/or e-rates. The examples of government interventions in Kenya and South Africa have been cited.

ii. ICT sector policy makers and regulators have a major role to play. The restrictive regulatory environment in the majority of African countries is the greatest cause of high bandwidth costs. The principle enabler of price reduction is open competition combined with quality control so that consumers, including educational institutions, get good quality at the best prices the markets can offer. In addition to this, NRENs, with the clear understanding that they will reach out through different mechanisms to all levels of education, should be permitted to own and operate independent national networks for their closed user group; own and operate international gateways (including fibre); and transit traffic for NRENs in neighbouring countries. Interim measures that can help schools to get connected could include e-rates as a regulatory requirement as well as access to universal access funds for connectivity, computer labs, and mobile access devices.

iii. Before any NREN can offer services, they need to invest in both the network and human resource, even with the basic agency model that relies on outsourced services. This stage is a major challenge for all start-up NRENs. The first need of NRENs is therefore start-up capital. The most advanced NRENs in sub-Saharan Africa, TENET (South Africa) and KENET (Kenya) both benefited from major start-up grants from development partners, and later internal infrastructure support from their governments. Governments can enable NRENs by addressing the capital and recurrent costs of NRENs on a phasing out basis for at least three years. This support should also be available on a continuing basis for major capital outlays, like high capacity internal data networks and external connectivity. Like the NRENs, the member institutions themselves need support for the implementation of good campus networks, and must be a logical

starting point for a holistic programme of government support. This ranges from primary schools to universities.

iv. The challenge of human capacity is quite often about poor curricula and lack of effective linkages with industry. There should be a requirement for regular industry input into university curricula, involvement of people from industry as occasional lecturers, and an internship requirement for students. The industrial training levy as well as obligatory absorption of students for internship – supported with suitable incentives like tax breaks – need to be implemented or reinstated where they no longer exist.

v. Content networks are the lifeblood of NRENs. Promotion of institutional collaboration, joint applications, eduroam programmes[51], grid computing, and academic video conferencing (as examples) lead to the desired development impact of NRENs and at the same bring out their real value. Many of these content networks will themselves need coordinated support from governments.

4.2 Recommendations to Development Partners

Development partners have several points of intervention to enable NRENs, many of them related to the areas where government also needs to intervene:

i. The main data backbones: this includes both the transmission path (ideally fibre) and active devices to light up the fibre and manage the traffic.
ii. The last mile connection to institutions. It is expected that wireless solutions would be used quite a lot for last mile connectivity. Heavy usage institutions like universities should have fibre.
iii. Data centers are an expensive resource to set up and operate.
iv. Capacity building support
v. Content networks: Library; e-learning; grid-computing; agriculture; medicine and e-health are some of the sectors where there already exist established or emerging content networks.

In addition to these, RRENs face a challenge in that institutions like the World Bank and ADB tend to work at the national level. An entry point needs to be found for RRENs so that they can also be enabled in playing their role.

[51] Eduroam refers to education roaming and allows students, researchers and staff from participating institutions to obtain internet connectivity across campus and when visiting other participating institutions through their laptop. http://www.eduroam.org/

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