

NATIONAL RESEARCH AND EDUCATION NETWORKS (NRENs)

Understanding NRENs and key considerations for setting them up

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1 INTRODUCTION

This paper was inspired by a recent assignment to support the provision of high speed and affordable connectivity for educational institutions in a southern African country. The assignment resulted in a proposal to establish a dedicated educational Internet Service Provider (ISP) for all educational institutions at all levels (universities, teaching training colleges, schools, libraries, museums and research institutes) building on an already existing innovative and functional ISP for primary and secondary schools and a framework to provide connectivity for social and economic development sectors. In many respects, such an educational ISP is akin to a National Research and Education Network (NREN). In the course of the assignment, I undertook extensive research on existing NRENs, their meaning, nature, growth and sustenance. I have coupled this research with my own experiences and reflections on NREN development in Africa to produce this paper. The paper is meant to share some of my findings and reflections to inform current efforts to create NRENs elsewhere in Africa.

The paper is divided into 4 sections:

Section 1- In the first part of the paper, I have reviewed existing NRENs and NREN initiatives in North America, Europe, Australia and Africa to understand what NRENs are, their origins (sometimes a little history is instructive), what drives their creation, what they do, who they benefit and why they are important.

Section 2- In the second part of the paper, I distil the lessons learned from the first section, various research reports and my own experiences to arrive at a number of “considerations” meant to inform nascent as well as existing NREN development efforts in Africa. Such considerations include a) a clear understanding of physical network architecture (included is a detailed discussion of national infrastructural issues), b) Ownership models for the NREN infrastructure, and c) the effect of size of country and number of institutions therein or what I collectively term “scale,”

Section 3- In this section, I consider the issues involved with starting up, managing, governing, operating and staffing NRENs as well as the financing and funding issues.

Section 4- The paper concludes by discussing what existing NRENs can do to better serve their members and making a number of proposals to advance NREN development and expansion efforts in Africa. These proposals are meant to build onto, accelerate and complementing current efforts underway.

I hope that this paper will stimulate further discussion and thinking in the African NREN development arena.

2 UNDERSTANDING NRENs

This section provides some background information on NRENs- what they are, their origins, what drives their creation in the first place and the benefits they confer. This section draws heavily from a review of existing NRENs in North America, Australia, Europe and Africa coupled this with my knowledge and experiences of NREN development in Africa.

2.1 *What is an NREN?*

There exists some confusion as to whether NRENs are collaborative human networks or physical telecommunication networks. From a review of various NRENs in Europe, Australia and North America, it appears that the term NREN usually refers to the organization that designs, builds or leases, operates, maintains, supports and manages a physical telecommunications network for the benefit of the education and research community. The physical telecommunications network (the NREN physical network) connects education and research institutions directly to each other, to other NRENs and to the “commercial” or “commodity” Internet. The NREN physical network is, in reality, usually a “private network” or “closed network” dedicated to the education and research community. The connection to the commercial Internet is often achieved either through peering arrangements with commercial Internet Service Providers (ISPs) at national Internet Exchange Points (IXP) or through direct connection to a Tier 1 or large Tier 2 commercial Internet provider outside the NREN’s country.

In some countries, the NREN physical network and the NREN organization have different names while in others, they are indistinguishable in name. Examples of the former include: the United States’ Internet2 which is the NREN organization comprising of a consortium of educational, research, government and private entities while Abilene is the physical telecommunications network, the United Kingdom’s (UK) UKERNA (United Kingdom Education and Research Networking Association) is the organization while JANET (Joint Academic NETWORK) is the physical network and in Canada, CANARIE is the organization while CA*Net 4 is the physical network.

Another view¹ is that NRENs are primarily human networks and their accompanying organizational structures for producing and sharing knowledge and for promoting a continuous research agenda. The physical telecommunications networks and other Information and Communication Technologies (ICTs) are enabling tools for the production, distribution, sharing, management and utilization of knowledge. The human networks are the users and beneficiaries of the physical network.

In order to keep with convention, the term NREN will be used to refer to the organization that manages the physical academic and research network.

¹ Articulated by Steve Song of IDRC and Prof. Akilagpa Sawyerr of the AAU at various conferences and workshops

2.2 The Origin and a brief history of NRENs

NRENs were originally a product of academic research to find efficient and cost effective ways to share scarce, expensive computer resources, to communicate and to collaborate by researchers and academics in the early 1970s. The United States was at the forefront of this research and established the first “national level networks” serving the academic, research and military community². Some of the earliest formal NREN networks include UNINET in Norway established in 1976,³ Computer Science Network (CSNET) in 1981 and later NSFNet in 1985⁴ in the US, Joint Academic NETwork (JANET) in the UK in 1984⁵, the Swiss Education and Research Network (SWITCH) in 1987⁶, NORDUNet for the Nordic countries in 1988 and CA*net in Canada in 1990.

These early research networking efforts can be said to have changed the world; they gave birth to the Internet. In some cases, these early NREN networks also developed their nations’ first national Internet backbone infrastructure. For example, in Canada, CA*net was for many years the only Internet backbone in the country,⁷ and in Australia, the early national backbone infrastructure was established and run by the Australian Academic and Research Network (AARNet).⁸

In Africa, as elsewhere in the world, the rise, if not the birth, of the Internet can be attributed to the universities and the general academic and research community. Countries where the universities introduced or pioneered access to the Internet (using TCP/IP) include South Africa (UNINET made its first TCP/IP connection in 1991), later followed by Zambia in 1994 when the University of Zambia established ZAMNET, the country’s first ISP and Mozambique in 1995 with Eduardo Mondlane University going online⁹.

And amazingly, NRENs feature prominently in Africa’s early Internet history! The earliest physical academic and research network in Africa can be traced to South Africa with the establishment of UNINET in 1987, and later Tertiary Education NETwork (TENET) in 2001¹⁰. The first physical inter-nation academic and research network in Africa was the East and Southern Africa NETwork (ESANET) established in 1991 with funding from the International Development Research Center (IDRC) and connecting universities in Uganda (Makerere University), Kenya (University of Nairobi), Zambia (University of Zambia) and Zimbabwe (University of Zimbabwe)¹¹. ESANET provided

² See A Brief History of the Internet- <http://www.isoc.org/internet/history/brief.shtml>

³ A History of NORDUNet, http://www.nordu.net/history/TheHistoryOfNordunet_simple.pdf

⁴ See A brief history of the Internet and NSF, http://www.nsf.gov/news/special_reports/cyber/internet.jsp

⁵ See A brief history of JANET, <http://www.ja.net/about/brief-history.html>

⁶ See The SWITCH foundation, <http://www.switch.ch/about/foundation.html>

⁷ See <http://www.canarie.ca/advnet/history.html>

⁸ <http://www.aarnet.edu.au/about/history.html>- In fact, AARNet is claimed as the “genesis” of the Internet in Australia

⁹ Partnership for Higher Education: see Rowing Upstream and Securing the Linchpin

¹⁰ See The Partnership for Higher Education in Africa, <http://www.foundation-partnership.org/linchpin/profiles.php>

¹¹ Elizabeth Levy and Stacey Young (Eds), 2002, Rowing Upstream, Snapshots of Pioneers of the Information Age in Africa

email services using fido mail, a store and forward email system and heralded the beginning of the Internet in these countries.

2.3 Why are NRENs created?

In the 1970's and 1980's NRENs were created to fulfill the demands for advanced research, communication and collaboration. At that time, there were simply no networks in the countries that the academic and research community could use and so they built their own. With the growth and proliferation of commercial networks and network providers now available in every country, one would have assumed that there is no longer a need for dedicated academic and research networks provided by "special dedicated institutions- NRENs"¹². Instead, NRENs and NREN networks continue to grow and expand all over the world. The question is why?

According to a SERENATE report¹³ investigating European NRENs, the education and research community has special needs that can not be met by commercial internet and network providers for a number of reasons that taken together do not "offer a compelling business case" for the commercial providers to try to meet the needs of the community. Some of these reasons include:

- The infrastructure, services and applications required for advanced research are very expensive to provide and would require significant investment.
- The education and research community is not one with "a very significant purchasing power."
- The education and research community is small in size compared to the business sector and the general public.

The report further argues that for commercial network providers, "it is more interesting to concentrate on providing services to businesses and the general public, a market that requires less investment and offers a faster return on investment." As a result, the academic and research community often has no choice but to collaborate and build, operate and manage their own dedicated network. And since education and research are considered cornerstones of economic and social development (and "are areas of government responsibility in their own right"), NRENs usually benefit from considerable government funding and support.

NRENs can therefore be considered to be a product of "functional need" and "economic advantage" as articulated by Leatt and Martin (2000).¹⁴ The functional need is driven by

¹² SERENATE or the Study into European Research and Education Networking As Targeted by eEurope carried out a series of brilliant studies in the strategic aspects and challenges to European NRENs. The results of these studies are most informative and some of the lessons learned applicable to African NREN development. The reports of the studies can be found at <http://www.serenate.org/publications/>. For information on why NRENs are created, see SERENATE report Deliverable See SERENATE report Deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/d21-serenate.pdf), <http://www.serenate.org/publications/d21-serenate.pdf>

¹³ See SERENATE Deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/), <http://www.serenate.org/publications/>

¹⁴ Leatt, J.V and Martin, D.H 2000, Reflections on collaboration within SA Higher Education by two

the communities own reason for existence: to undertake research for community, social and economic development. The economic advantage is realized by acting together to pool resources and leverage economies of scale. Four specific drivers of NREN creation and growth can be identified: a) the need to share expensive research equipment and applications b) the increasing demand for high-capacity networks for advanced and collaborative research c) the need for cheaper and more bandwidth¹⁵, and d) the need to foster a collaborative community. A detailed discussion of these drivers follows.

a) The need to share expensive specialized research equipment and applications

The earliest NRENs (such as NSFNET¹⁶).were created to enable scientists and engineers to access and share super computing facilities. Establishing a super computer center or other such advanced research facility is often beyond the financial ability of any one institution. It is far cheaper to establish a few such facilities and have several institutions share the facilities. This gives rise to the need to share expensive facilities without physically having to travel to the facility itself. This need continues to drive NREN creation and growth especially in North America and Europe. Other specialized research equipment often shared includes radio telescopes and particle accelerators. On the application side, there is also a need to share large databases and databanks such as digital libraries, journal holdings and DNA banks.

b) Advanced research needs

The SERENATE report on the networking needs of users in the European research community¹⁷ has identified some of the more common advanced research fields and activities that require very high-capacity (often Giga bit) networks fuelling the growth of NRENs. Some of these research fields and activities include:

- Large scale collaboration especially in areas such as earth science (climate research and oceanography), nuclear science and environmental science
- Conducting large scale simulations
- Research into collaborative computing, distributed computing and grid computing
- Real time remote sensing and visualization
- Transferring large data sets e.g. satellite images, movies for linguistics studies
- Medical applications such as remote diagnosis, computer aided surgery, sharing medical and clinical data efficiently
- Videoconferencing for meetings and collaboration

bloodied but unbowed participants

¹⁵ Bandwidth as used in this paper refers to the capacity of a communications link

¹⁶ National Science Foundation, A Brief History of NSF and the Internet, http://www.nsf.gov/special_reports/cyber/internet.jsp

¹⁷ See SERENATE report Deliverable [D10: Report on the networking needs of users in the European research community](http://www.serenate.org/publications/), <http://www.serenate.org/publications/>

- Testing advanced and often high-bandwidth network concepts and applications

The super high-speed (Giga bit and more) networks required are often beyond what the commercial internet can offer. Therefore, the academic and research community often has to create its own advanced high-speed network. Most of these super high-speed networks are often experimental and at the cutting edge of research into telecommunications networks. Some NRENs will also provide a separate experimental network, for example, part of the UK's JANET also includes a separate network for advanced research and "experimental activities in network development."¹⁸

The need to share specialized expensive research facilities and the increasing focus on advanced research activities initially drove and continues to drive the growth of NRENs in the US (Internet2) and in Europe (GEANT).

c) Access to more and cheaper internet bandwidth

This seems to be the main driver of NREN creation outside North America and Western Europe and certainly is the main driver in Africa. In today's knowledge and information age, the Internet is critical for communication, collaboration and access to educational resources like e-content and e-journals (a functional need). Unfortunately, most African and other less developed countries else where in the world often have commercial providers with low capacity networks and extremely high bandwidth charges. By pooling their internet bandwidth purchases, academic and research institutions can leverage economies of scale and obtain bulk discounts to reduce access costs (an economic advantage). To achieve this aim, institutions will establish a "bandwidth consortium" with a central management organization acting as an "agent" for the consortium, purchasing bandwidth in bulk and reselling it to the consortium institutions¹⁹. In some cases, this central agent acts as a fully fledged ISP offering a full range of services such as authentication, bandwidth management, hosting, email and other applications. This central management agent is sometimes referred to as the NREN.

Some argue that the internet bandwidth or ISP focus of these consortia management agents does not qualify them to be called NRENs as they do not (directly) address the issues of human networking and collaborative research. While this is true, it also ignores the reality of the situation in Africa and other less developed parts of the world and that is that even basic research is hindered by the lack of access to journals and other educational resources and ability to communicate and collaborate easily. Access to more and cheaper Internet bandwidth could help alleviate some of these hurdles and will be a priority for African NRENs. In fact, a recent report²⁰ on investments in African NRENs concludes that African NRENs "may be driven, at least in an initial phase, more by the need for more bandwidth than by the need for secure, closed networks on the model of Northern NRENs". The good news is that once the infrastructure is established, bandwidth increased and costs lowered, most of these bandwidth consortia or "ISP – type" NRENs move on to providing more advanced networking services for research purposes.

¹⁸ See About Janet, <http://www.ja.net/about/index.html>

¹⁹ TENET in South Africa is a classic case of an agent- see <http://tenet.ac.za/>

²⁰ See PAREN report at www.connectivityafrica.org/HTML/PAREN_investment_report_final.pdf

d) Fostering a collaborative community

This seems to be a “higher level vision” rather than a direct driver of NREN creation. However, it is important to consider because it forms a fundamental part of the essence of academic and research networking. Interesting examples can be gleaned both in Africa and Europe. In 2005, the results of an analysis of several questionnaires sent out to several people involved in promoting the academic and research networking agenda in Africa concluded thus: “The motivation for a collective approach to addressing the challenges and opportunities of ICT, among which bandwidth is now prominent, in African academic and research institutions is to: foster regional cooperation that provides the framework for collectively mobilizing resources, initiating policy reform and sharing experience so as to secure affordable access to ICT and ensure its effective integration into the process of teaching/learning, research, information management and dissemination in higher education in Africa.”²¹

Similarly, the UK’s UKERNA opines thus: “The concept of a community underpins everything UKERNA does and the network is based on the need for organisations to communicate, collaborate and co-operate in the shared interests of education and research”²².

2.4 What do NRENs do?

NRENs provide a multitude of services to their members. The most obvious ones are related to their key drivers discussed in detail in the preceding section. Some of the major services offered by NRENs are.

- a) Provision a dedicated physical network
The typical NREN’s most obvious and over-riding objective and function is to provide the academic and research community with a dedicated, reliable, high-speed physical telecommunications network and connectivity to support the education and research agenda.
- b) Provide Internet access
The NREN is usually responsible for negotiating, on behalf of all participating institutions, favorable pricing for internet access and provisioning this Internet capacity to its members over the NREN physical network.
- c) Provide network services and applications
The NREN also provides services such as:
 - Web hosting for all its members
 - Domain Name Services (DNS)

²¹ Paper by Dr. F. Tusubira for the Association of African Universities, 2005, Defining The Strategic Framework For AAU Action in Addressing Bandwidth and Broader ICT Challenges For Education and Research Institutions in Africa, Questionnaire Responses – Analysed to provide a strategic framework

²² <http://www.ukerna.ac.uk/about/ukerna/ukerna.html>

- Network security and security advisory services
 - Email hosting, spam filtering and web mail services
 - Bandwidth management (e.g. web caching and traffic shaping)
 - Network time services
 - Large network storage space
 - Collocation services
 - IP telephony
 - Authentication, Authorization and Accounting (AAA) services
 - Videoconferencing and voice conferencing services
- d) Support teaching and learning
NRENs leverage their networks and services to promote new and innovative ways of teaching and learning. For Example, in the UK, JANET's videoconferencing services are used for distance learning²³.
- e) Support advanced research
The NREN network is used to carry out research into “next generation” internet technologies, protocols, services and applications. For example, Internet2's Abilene network is billed as “a proving ground for high-bandwidth technologies”²⁴
- f) Undertake research
NRENs also undertake their own research into advanced networking concepts and applications. In undertaking this research, they often engage, partner and collaborate with their member academic and research community.
- g) Promote linkages with other sectors
NRENs can and do promote linkages between the academic and research community and industry, government and other international research and educational networks. Of special interest to NRENs is the ability to transfer research into advanced networks and applications to the commercial sector to benefit society at large.
- h) Provide advisory services
NRENs provide centralized advisory services and expertise that would be too expensive for each educational or research institution to procure and develop on its own. Such expertise and services might include bandwidth management and security services such as intrusion detection, incident response and management. NRENs also offer managed services for border routers and servers for its member institutions.
- i) Promote the interests of its member community
NRENs often promote the interests of its member community through lobbying, conducting awareness campaigns, providing timely communication and information and through engagement with government, the public and the international community. NRENs have usually been heavily involved in the formulation of national ICT policies.

²³ See About JANET, <http://www.ja.net/about/index.html>

²⁴ <http://abilene.internet2.edu/>

- j) Provide services to the general public
NRENs also provide specialized services to the wider internet community in a country such as domain registration services or running the national IXP. For example, NRENs are domain name registrars in some countries (e.g. SWITCH in Switzerland manages the .ch and .li domains, the Egyptian EUN is the manager of the .eg domain²⁵ and Eduardo Mondlane University in Mozambique manages the .mz domain) while NRENs run Internet Exchange Points (IXP) in some other countries (e.g. Denmark's UNI-C runs the national IXP²⁶)

2.5 Who are the members or beneficiaries of NRENs?

NRENs have traditionally been formed by and to serve universities (defined as degree granting academic and research institutions²⁷) and specialized research (especially post graduate or professional research) institutions coming together to collaborate and share academic and research knowledge and resources. Increasingly, NRENs in North America and Europe have opened up to other higher education institutions²⁸ (polytechnics, community colleges, teacher training colleges, vocational training institutions) and even, in some cases, to all institutions in the education sector including primary and secondary schools, public libraries, museums, archives and any government or public departments involved with education and research. Many NRENs are also actively connecting other non education social sectors such as health and local government as well as Non Governmental Organizations (NGOs) active in these sectors.

In Africa, NRENs are also usually formed by and serve universities and university-level institutions. As will be discussed later (see section 3.3), it is probably not wise for African universities to limit the membership of NRENs to university-level institutions only. This is because most African countries lack the necessary scale, in terms of number of universities and research institutions, and this makes NREN creation and operation much more expensive (on a per institution or per user basis) than countries with many institutions. African NRENs under development might have to consider serving the wider educational community from the very start.

2.6 What are the benefits of forming an NREN?

NRENs are a classic case of “the whole is larger than the sum of its parts”. NRENs benefit their members; but also more importantly NRENs contribute significantly to their nations’ overall technological economical development. As argued by the SERENATE summary report²⁹, NRENs are a source of innovation often transferring technologies and services to “society as a whole, and especially to high-technology industry”. Actually, the Internet itself is a product of academic and research networking. And so is the World

²⁵ <http://www.eun.eg/docs-n/e-dns.php>

²⁶ <http://www.denet.dk/history/>

²⁷ See Wikipedia, <http://en.wikipedia.org/wiki/University>

²⁸ As used here refers to any tertiary, post secondary or third level institution—see Wikipedia at http://en.wikipedia.org/wiki/Higher_education for a full discussion of higher education

²⁹ See SERENATE report Deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/d21-serenate.pdf), <http://www.serenate.org/publications/d21-serenate.pdf>

Wide Web. Additionally, the majority users of NRENs are “young, very well educated and dynamic” and move constantly from academia and research into industry and commerce taking with them significant knowledge and skills of advanced network concepts and applications thereby stimulating the introduction of new services to and by the technology industry. This constant transfer of innovation and new technologies makes NRENs a national “asset for economic growth and prosperity” which governments should nurture, support and fund as part of their overall economic development or poverty reduction strategy.

NRENs also transfer significant benefits directly to their member institutions. Some of these benefits include:

- **Cheaper and more bandwidth**

The NREN can aggregate internet access demand from all its users and leverage economies of scale to achieve lower prices and therefore more bandwidth for the same amount of money spent by the institutions.

- **Increased negotiating power**

The cohesiveness of the community expressed through the NREN tremendously increases the negotiating power of the community. This negotiating power can be used to further reduce bandwidth costs and can even be extended to acquisition and management of many other forms of ICTs.

- **More efficient use of bandwidth**

If well designed, NRENs help keep local traffic local thereby reducing the amount of expensive international bandwidth required. By keeping local traffic within the core network, NRENs can also tremendously boost access to educational and research content such as e-journals and e-content by establishing local mirrors.

- **Increased influence**

The Nordic’s countries NORDUNet puts it best: “By speaking with one voice, the Nordic countries have much more weight in international networking collaborations.”³⁰ This sort of influence makes lobbying more effective and can be used to promote the interests of the community among private industry and governments.

- **Increased collaboration and a sense of community**

NRENs by their very nature promote collaboration and foster a distinct sense of community among researchers, academics and wider educational community. The fact that NREN creation requires collaboration between educational and research institutions reinforces the collaborative community approach to tackling challenges, sharing resources and collectively benefiting from the NREN

- **Shared expertise**

Most African educational and research institutions can not afford to hire people with skills such as those possessed by advanced networking specialists, network security specialists and project management specialists. By forming an NREN, the entire

³⁰ http://www.nordu.net/history/TheHistoryOfNordunet_simple.pdf

academic and research community can benefit from centralized expertise and the cost to each institution to acquire such expertise is lowered as it is shared.

3 CONSIDERATIONS FOR CREATING AN NREN

This section explores some of the major issues and challenges that African NRENs are likely to encounter in their development. It reviews and attempts to capture lessons learned from other parts of the world and from within Africa itself to arrive at some “considerations” to inform NREN development and operation in Africa.

3.1 The physical telecommunications network model

One of the important things to understand when considering setting up an NREN is the telecommunications network model and how it applies to a specific country. The layered network model discussed in the InfoDev report on Open Access³¹ is informative. The model consists of three dimensions: layer, reach and type of customer. For NRENs, the important dimensions are the layers and the reach. From the Open Access model, one can derive a model for NRENs, shown in figure 1 below.

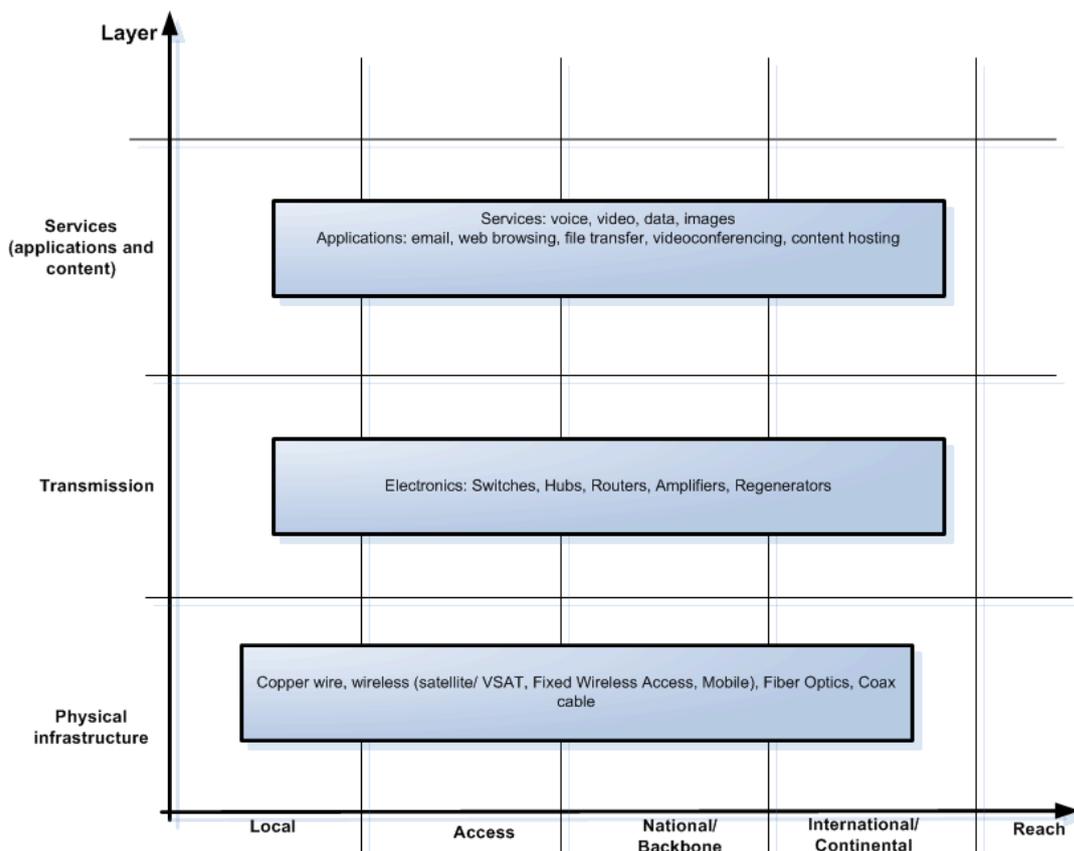


Figure 1- Network Model

³¹ InfoDev, 2005, *Open Access Models*, Options for Improving Backbone Access in Developing Countries (with a Focus on Sub-Saharan Africa), *Final Draft An infoDev Technical Report* prepared by SPINTRACK A B

There are three layers: the passive physical infrastructure, the logical transport and transmission system and the services (applications and content). The interface between layers is typically standardized by technical protocols and agreed upon business contracts and Service Level Agreements (SLAs).

The reach of the network is the “geographical scope of the providers.” Another way of looking at this is that telecommunications networks consist of various levels each with a distinct geographical domain and each level often provided and managed by a different organization. There are four main levels or geographical domains of interest to NRENs: local, access (metropolitan or regional), national and international levels. Networks at various levels are usually interconnected through “points of presence” or POPs. The networks that exist at various levels are detailed below:

- The local network is the internal institutional network commonly called the “campus network” and this is the one “closest to the end user”. The local network is owned and managed by the institution.
- The access network is the portion between the institution and a high speed, usually nation-wide network (or the “national backbone”). It is also known as the “last mile.” The access network is usually owned and managed by different commercial ISPs, telecommunication services resellers and major telecommunications companies. Examples of access networks include Metropolitan Area Networks or Regional Networks.
- The national network or national backbone is the high-speed network linking major towns and cities in a country usually owned and operated by the national or other major telecommunications companies.
- The international network connects the national network to other national networks or to continental or international networks. It is also usually owned and managed by national or other major telecommunications companies.

The access and national backbone segments of the network are usually together termed “national infrastructure”. In Africa, these segments of the telecommunications network are usually of low capacity, unreliable and only available in the major metropolitan areas. These weaknesses of the national infrastructure have led to the proliferation of VSAT networks in Africa as they bypass the national infrastructure connecting the local institutional network directly to international or continental networks. The implications of poor national infrastructure and the use of VSATs will be examined in more detail in the proceeding sections.

In Africa, NRENs are going to have to decide where they draw the line on which network layers and levels they will own or lease, manage or outsource or leave to the institutions.

3.1.1 The reach of NREN networks

The reach of NRENs in relation to the telecommunications model discussed above usually involves 2 or 3 levels: the access network, the national network and the

international network. The local network is always provided by the institution. The other 3 levels are discussed in detail below:

- **NREN Access Network**

Some NRENs do not provide the access network, instead providing POPs on their nation-wide (or core) networks for institutions to connect to. Other NRENs provide an access network or extend the core network directly to the institutions (the majority of NRENs in Europe connect directly to the institution³²). As acknowledged by the SERENATE summary report³³, direct connection is usually more feasible where there are a few institutions. With many institutions numbering in the hundreds or even thousands, NRENs will usually provision POPs in major cities and towns and institutions have to obtain their own access connection individually or collectively. With most African countries have a few higher education institutions, even fewer research institutions and very poor national infrastructure, NRENs will have to seriously consider provisioning the access network or connecting institutions directly to their core networks.

- **NREN backbone or core networks**

All NRENs provide a nation-wide high speed network also known as the “core or backbone network” with POPs at which institutions can connect to it. This core network allows institutions to exchange traffic directly and to aggregate traffic destined for other NRENs or international networks. The core network can be provisioned over fiber, the traditional copper cables or via radio networks although most NRENs in the more developed world have moved to fiber only core networks³⁴. According to the TERENA compendium 2006 some NRENs “do not have a core backbone, for example, because they have a star topology.”³⁵ The same report notes that within the EU and Eastern Europe, NRENs’ core capacity has in most cases been upgraded to at least 1 Gbps with many NRENs expected to upgrade to at least 5 Gbps by 2008. Instructive for African NRENs is the core capacity of the Algerian and Moroccan NRENs with core capacities of 310 and 155 Mbps.

- **International connections**

NRENs also usually provide an international link(s) to a continental Research and Education Network or REN (for example in Europe most NRENs connect to GEANT), which in turn is peered with major commercial telecommunications services providers and/or a direct connection to the commercial internet. The connection to the commercial Internet is usually through a peering arrangement. According to the SERENATE summary report, “It is the general policy in Europe that NRENs should off-load traffic with a destination in the commercial Internet onto the networks of commercial Internet Service Providers at the earliest economically viable opportunity” which usually means

³² See Chapter 2 of the TERENA Compendium 2006, <http://www.terena.nl/activities/compendium/>

³³ See SERENATE report Deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/), <http://www.serenate.org/publications/>

³⁴ See SERENATE report Deliverable D14 Report discussing the future scenarios for the funding of network infrastructure in the European research networking community and of related costs, <http://www.serenate.org/publications/>

³⁵ See Chapter 3 of the TERENA Compendium 2006, <http://www.terena.nl/activities/compendium/>

offloading to the nearest Internet Exchange Point after which this traffic is carried by a commercial ISP.

3.1.2 Local vs. National vs. International Connectivity

When it comes to aggregating bandwidth, most institutions and NRENs in Africa seem to focus on international bandwidth and seldom, if ever, consider the national and local bandwidth requirements. Perhaps this is because the main driver for connectivity has been to access information resources and for basic communication like email, which as the AAU bandwidth Initiative report³⁶ notes “unfortunately still means access to servers in Europe and the Americas.” Further, if institutions are connecting by VSAT directly to the international backbone, as is often the case in some parts of Africa, the issue of national bandwidth does not arise.

However, NRENs should consider all their access, national or backbone and international bandwidth portions holistically. There are three main reasons why this is important:

- a) Increasing international bandwidth without paying attention to access, national and even local bandwidth might be a waste of valuable funds. If the local and national networks are congested or slow, they will act as a bottleneck making it impossible to maximize the use of international bandwidth.
- b) National rather than international bandwidth is the driver for local inter-institutional collaboration and for sharing expensive resources such as super computing facilities or e-content within a country.
- c) Even of more critical importance is the need to realize that *access and national bandwidth is often the same cost or even more expensive than international bandwidth.*

The issue of local institutional connectivity is worth highlighting. The AAU Bandwidth Initiative report acknowledges that good local infrastructure and policies are “pre-conditions” for the efficient exploitation of expensive bandwidth resources [35]. The SERENATE report on the networking needs of users in the research community in Europe also finds that the “major source of limited network performance is primarily at the campus”³⁷. The report recommends that this fact should be “drawn to the attention of senior management in universities and similar sectors”. The report also acknowledges that convincing universities to invest in their campus networks is “remarkably difficult” even while the universities spend “six or eight times more money on other infrastructural services like telephone, electricity, water and heating.” Clearly this is challenge that NRENs are going to have to address as a priority one way or another. Perhaps this is why

³⁶ Tsubira, F.F and Mulira, N.K, 2005, Report on the proposed role of the AAU: enabling member and associated institutions to access more bandwidth at lower cost

³⁷ See SERENATE report Deliverable [D10: Report on the networking needs of users in the European research community](http://www.serenate.org/publications/), <http://www.serenate.org/publications/>

some NRENs like Uganda's RENU have made "a well developed campus infrastructure" a pre-condition for membership of the NREN³⁸.

3.1.3 The use of VSATs

In many parts of Africa, the national infrastructure is very poor and limited in coverage. The solution to providing good internet access for institutions in these countries has been to deploy VSATs with international connections. NRENs in these countries might consider providing a VSAT with international connections for each and every (or for the majority of) institution. This strategy might work where there are a few institutions to be connected. However, when there are tens or even hundreds of institutions to connect, then this might not be the most economical or efficient way of connecting Institutions. Some drawbacks of connecting all institutions with VSATs with international links are:

- The cost of provisioning 50 or even 100 VSAT equipment kits is very high (at about US\$ 40,000 plus for a VSAT kit capable of high-capacity transmission). Compare this with the cost of deploying own fiber on existing pole lines at \$2,000 per km or cost of laying fiber on own pole line at \$10,000 per km or even cost of fiber in ducts at about \$30,000 per km³⁹ together with the amount of bandwidth that fiber would provide vs. the bandwidth available using VSAT. Since higher educational institutions are likely to be clustered around towns and cities, it might make sense to deploy one or two VSATs to be shared among institutions in one location and link the institutions together by own fiber or leased capacity from existing providers.
- The use of VSATs means that two institutions say 5 miles apart needing to exchange emails will need to use expensive international capacity. With every institution having its own independent VSAT with international link, exchange of information between institutions in the same country will require the use of expensive international bandwidth thus undermining the need to efficiently communicate and collaborate in an affordable manner.
- VSATs are not suitable or even feasible for very high speed, real time and low latency applications usually associated with the high end computing demands of scientific applications and research.

Therefore VSATs seem to be a financially feasible option only if the number of higher education institutions in the country is small and their bandwidth requirements are low. Countries with many higher education institutions might not find it economical or efficient to acquire a VSAT for each and every institution.

However, there are a few instances in which the use of VSATs is indeed unavoidable and necessary:

³⁸ See <http://www.renu.ac.ug/>

³⁹ Fiber prices from the SARUA study -- See page 28 of the SARUA report at <http://www.ubuntunet.net/documents/Sarua-fibre-final-report-draft-2006-03-04.pdf>

- Connecting institutions in very remote areas: Institutions in very remote areas where there is no existing national infrastructure and where it would be prohibitively expensive to provide own fiber can still be connected by VSAT to the NREN national or core network. The VSAT system in this case is not used for international capacity but rather forms part of the NREN national infrastructure. This is akin to the use of VSATs by mobile phone companies as backhaul links to connect remote base stations to the central switching station. These sorts of “national VSAT networks” will still suffer from some of the draw backs of the general use of VSATs but can usually benefit from smaller, more powerful satellite beams (meaning smaller and cheaper antennas) usually positioned over a single country where they exist.
- Countries with no international submarine fiber: Instead of each institution having its own VSAT, the institutions can share one or two VSATs for their international links and connect to each other over a terrestrial network. The VSATs would act as international gateways and inter-institutional traffic would be kept local.

NRENs should carefully study the use of VSATs in their local context and examine alternative methods of connection where they exist. This is not to say that countries that rely mostly on VSATs due to lack of terrestrial infrastructure should not or can not form NRENs. To the contrary and as concluded by the announcement and call for proposals under the Fostering Research and Education Networking in Africa (FRENIA) program funded by the Andrew W. Mellon Foundation and run by South Africa’s TENET⁴⁰: “even in contexts where there is little terrestrial infrastructure and institutions are still reliant upon VSAT connectivity, there is plenty of scope for the formation of NRENs, as vehicles that can offer other services and can pave the way for fiber based networks.” In fact, an entry point for NREN creation in these countries is the aggregation of satellite bandwidth purchases through the NREN which would negotiate with one or a few providers for bulk discounts.

3.2 NREN network ownership models

According to the SERENATE report discussing the future scenarios for the funding of network infrastructure in the European research networking community and of related costs,⁴¹ there are four main ways (or models) by which NRENs can go about acquiring and deploying their networks. These are:

- i) **Build own infrastructure:** NRENs can build their own networks (full ownership) or by partnering with another provider (e.g. through a joint venture). This would involve laying own fiber and provisioning necessary transmission equipment or by deploying wireless systems such as microwave links. The NREN (or its joint venture partners) can operate and manage this infrastructure itself or outsource operation and management.

⁴⁰ See <http://tenet.ac.za/frenia/>

⁴¹ See SERENATE report Deliverable D14 Report discussing the future scenarios for the funding of network infrastructure in the European research networking community and of related costs, <http://www.serenate.org/publications/>

- ii) **Lease infrastructure:** NRENs can lease existing but unused infrastructure e.g. dark fiber from telecommunications providers or other entities such as electricity and rail companies. In this case, the NREN would provide its own transmission equipment (amplifiers and regenerators for fiber systems or antennas and transceivers for microwave system with the provider availing towers, power and backhaul links). More information on the availability of and possible business models of using dark fiber by NRENs in East and Southern Africa can be found in the SARUA study on Optical Fiber for Education and Research Networks in Eastern and Southern Africa⁴².
- iii) **Purchase managed services:** The NREN would lease dark fiber or dedicated wave lengths on fiber or dedicated channels on microwave links with the telecommunications providers owning all transmission equipment
- iv) **Purchase capacity:** NRENs would purchase capacity or bandwidth from service providers between two or more points. In this case, the NREN network is usually a VPN.

Traditionally, NRENs in places like Europe have simply purchased capacity from existing providers and created VPN type network possibly because this model does not require NRENs to outlay large amounts of cash for infrastructure provision. However, European NRENs are increasingly deploying their own infrastructure or leasing dedicated infrastructure. For Africa, NRENs are likely to combine two or more models, for example building own infrastructure to institutions located in remote areas, purchasing dark fiber where it exists and purchasing capacity where high speed networks exist.

3.2.1 Approach to selecting ownership model

The ownership model(s) selected will vary from country to country and depend on a number of factors such as:

- Regulatory regime and specifically if it allows for building own infrastructure
- Financing options or funding available
- Level of technical expertise available to the NREN
- The amount of short and medium term bandwidth/capacity required
- The types of applications that the NREN will support
- The extent, coverage and capacity of existing provider’s infrastructure

These factors and their relative implications for each type of model (considering only the NREN core network) are analyzed in the table below.

	Initial cost	Recurrent capacity cost	Existing providers’ capacity required	Existing providers network coverage required	Technical expertise required

⁴² Edited by Björn Pehrson, KTH and Margaret Ngwira University of Malawi, 2006, See <http://www.ubuntunet.net/documents/Sarua-fibre-final-report-draft-2006-03-04.pdf>

Model 1	Very High	Nil*	Nil+	Does not matter	Very high
Model 2	High	Nil*	Nil+	High	High
Model 3	Medium	High	High	High	Medium
Model 4	Low	High	High	High	Medium

*With Model 1 and 2, NRENs still incur recurrent costs for maintaining and servicing their own connections and transmission equipment but do not incur a monthly bandwidth charge.

+Models 1 and 2 do not require that existing service providers have high capacity networks as they do not rely on existing capacity.

Please note that the relative implications of these factors will vary, sometimes greatly, from one country to another and so this analysis should be taken as indicative.

The information required to actually make a decision on the most appropriate model requires a carefully study of the existence, reliability, performance and gaps in national infrastructure. This should ideally be one of the key first steps in NREN development. A few such studies have been attempted for Africa, the most informative and comprehensive being the SARUA study on Optical Fiber for Education and Research Networks in Eastern and Southern Africa⁴³. Such a study should also "map" the existing and planned coverage of the national high speed backbone and access networks (preferably of all the service providers in the country) to the location of ALL educational institutions. This survey would be extremely useful in determining where the gaps in infrastructure are, the existence and feasibility of using dark fiber and the current and potential capacities of existing infrastructure. This study of national infrastructure would also provide critical input into a suitable network design for the NREN.

3.2.2 Strategies for African NRENs

It is most probable that African NRENs under development will choose ownership models that do not require a large outlay of initial capital. This means probably purchasing managed services (model 3) or purchasing capacity (model 4). However, in this approach, they are likely to encounter a major problem: very few countries in Africa have an extensive high capacity network to support widely spread institutions and to provide the kinds of large capacity required by these institutions. The only way out for these NRENs might be to build their own networks and in this they will be constrained either by funding or by existing telecommunications regulations. This is therefore a paradox of some sort. The (easier and short term) solution might lie with convincing existing national network providers and access network providers to extend (to locations with higher education institutions) and upgrade (more capacity) their existing networks to serve the NRENs member institutions at a reasonable cost. This means that the national and access network providers must be given "a compelling business case" to invest in extending and upgrading their existing infrastructure.

⁴³ Edited by Björn Pehrson, KTH and Margaret Ngwira University of Malawi, 2006. See <http://www.ubuntunet.net/documents/Sarua-fibre-final-report-draft-2006-03-04.pdf>

In some African countries, the educational sector forms a relatively huge (potential) Internet services market by virtue of the fact that they are likely to have one of the largest installed bases of computers of any sector. With the current convergence of voice and data, increasing rises in data over voice traffic and an erosion of traditional voice revenues from land line services, service providers are likely to listen to anyone with a substantial bandwidth demand. Service providers will therefore be hard pressed to ignore an aggregated educational market that NRENs can create. There are two ways for NRENs in these countries to increase their influence and negotiating power:

- Create large scale: NRENs will have to unite and serve the whole higher or even entire education sector to create one huge purchasing block and thus create large scale. Having significant scale (which is explored in section 3.3) is an incentive for service providers to extend their networks. A telecommunications provider might be willing to extend its network to cover one university and a hundred secondary schools than simply the one university.
- Leverage high bandwidth demand: NRENs should understand that they could (easily) potentially become the largest single consumer of bandwidth in a country especially if they leverage significant scale by aggregating bandwidth for the wider higher education or even the entire education sector. Projecting short and long term total bandwidth needs and presenting this to providers might convince providers to lower prices of capacity and to upgrade their networks. If providers realize that NRENs might be ordering for capacity in Giga bits rather than kilo bits, they might be willing to make significant discounts and upgrade and extend their networks.

There are other strategies that NRENs can consider in countries with poorly developed national infrastructure:

- Joint Venture: Where NRENs have funds to build out some segments of the network but are unable to do so because of the telecommunications policy, NRENs should consider a joint venture with existing licensed providers. Of course such joint venture should be carefully crafted to be in the interests of the NREN.
- Position NRENs to benefit from Universal Access Funds: If NRENs are recognized as “public good” entities, they could benefit from Universal Access Funds run by some countries especially when it comes to extending their networks to rural or underserved areas.

3.2.3 Emerging opportunities for African NRENs

There are a few emerging trends and initiatives in Africa which should be of interest for NRENs as they could be exploited to develop and extend network infrastructure. Some of these trends and initiatives are:

- a) National Backbone initiatives: Some countries in Africa such as Ghana and Uganda are in the process of designing and developing new or extending and upgrading existing national backbones. NRENs in these countries should be lobbying the governments to build and extend networks to areas where higher educational

institutions are located and/or avail NRENs with dedicated capacity. This is an opportunity that NRENs can not afford to miss.

- b) **Municipal Networks:** There is an emerging model where municipal and local governments in the United States, Europe and more recently even South Africa are building their own network infrastructure (usually metropolitan area networks or access networks) and then leasing it to service providers under an “open access model”. It is not hard to envision that this trend is likely to catch on in the rest of the continent. NRENs should seek to identify such opportunities and to partner with local governments and service providers to extend such networks to educational institutions.
- c) **E-government initiatives:** Some countries in Africa such as Rwanda and Ghana have established e-government programs with significant funding from donors such as the World Bank. NRENs should lobby their governments to include NREN network development under such initiatives.

3.2.4 Routing and Switching

Irrespective of the ownership model(s) selected, NRENs usually provision their own switching and routing equipment. This is something that the NREN will have to take very seriously because in my experience, the major source of complaints of poor service from institutions can be traced to poor routing and switching of traffic. As one institution in my southern African experience told me, they would join the proposed educational ISP only if routing and switching was not left to the monopoly provider! Some reasons why routing and switching seems to be problematic to NRENs and the institutions include:

- Lack of understanding of who has responsibility for switching and routing in the NREN’s core network; whether the responsibility lies with the institutions or the NREN or the service providers.
- Poorly skilled staff of the telecommunications provider who are unable to provide proper routing and switching services.
- Refusal of the telecommunications provider to provide access to their backbone routers and switches for the NRENs to configure their own optimum routes.

For these reasons, NRENs are better off owning and managing dedicated switches and routers in the NREN network.

3.2.5 The effect of regulation

Education and Research institutions and NRENs in Africa are aware that regulation and national policy can significantly impact the cost and quality of internet access or the set up and operation of an NREN. Two of the most acknowledged effects of regulation are the high prices of telecommunications services caused by having monopoly providers and restrictive licensing for VSAT systems. However, there are other more profound effects of regulation specifically related to the set up and operation of NRENs. A SERENATE study⁴⁴ on the effect of telecommunications regulation on NREN set up and operation in

⁴⁴ See SERENATE report Deliverable No. 8, Report on Workshop on National Research and Education

Europe is very insightful. The report identifies both direct and indirect effects of regulation on the development of NRENs

Direct Effects include:

- The rights to own and operate networks:
Some countries' telecommunications regulations prohibit any institution except the (usually) state owned telecommunications provider or a Second National Operator (SNO) to build, own and operate telecommunications networks in any "public space" i.e. anywhere outside the institutional campus. Some regulations also prohibit the use of VSATs or operation of any form of international gateway. This means that NRENs in these countries can only purchase capacity or purchase managed services from existing licensed providers. This denies NRENs the option to consider ownership models that might be more cost effective or to build networks for special research purposes.

- The ability to obtain Rights of Way and construction permits.
The Right of Way is defined as the "legal right to pass through property controlled by another."⁴⁵ For telecommunications networks, this means the right to access existing or build own conduits, trenches, towers, pole lines or have access to "other physical locations that modern communications networks occupy."⁴⁴ In many African countries, only the licensed operators and other public utility companies have Rights of Way and therefore NRENs could have problems trying to establish their own networks. The Right of Way access even affects individual institutions that have several campuses in different locations and might want to connect these campuses together. These institutions would have problems trying to lay fiber or build wireless towers across public spaces such as roads or walkways. An interesting point on Rights of Way is made by the SARUA report⁴⁶ which notes that when building their networks, NRENs could potentially partner with existing infrastructure or utility companies like electricity distribution companies that already have Rights of Way.

Indirect effects are often referred to as "market conditions" and include:

- Lower prices for network services as a result of increased competition due to liberalization
- More variety of networks, providers and services
- Improved service quality brought about by competition

There is a wider question of regulatory status of the NREN. Should NRENs register and be recognized as licensed operators? As the SERENATE report notes, in some countries, NRENs have formal licenses while in others they operate in a "grey zone". An interesting example of the former in Africa is KENET which is licensed as "a private not-for-profit

Network models, <http://www.serenate.org/publications/>

⁴⁵ Improving Rights-of-Way Management Across Federal Lands: A Roadmap for Greater Broadband Deployment, Report by the Federal Rights-of-Way Working Group, April 2004, http://www.ntia.doc.gov/reports/fedrow/FROWReport_4-23-2004.pdf

⁴⁶ See page 28 of SARUA report at <http://www.ubuntunet.net/documents/Sarua-fibre-final-report-draft-2006-03-04.pdf> for an interesting discussion on business models of dark fiber

education network operator.”⁴⁷ The full answer to the question of status will depend on the particular country, its regulatory regime and a careful examination of the benefits and disadvantages of formal licensing. Whatever the case and as the SERENARE report recommends, NRENs should “seek to have their status clarified” if only to avoid falling afoul of regulation and accusation of unfair competition.

3.2.6 The issue of competition

NRENs can be accused of competing unfairly with privately owned commercial or public network infrastructure providers especially as they are government funded. African universities that own and operate ISPs will have heard this accusation leveled at them several times. The real issue behind this accusation seems to be one of loss of revenue:

- In many countries in Africa, universities are some of the largest buyers of bandwidth and any attempt to deprive the commercial telecommunications providers of this revenue (e.g. by establishing independent VSAT links) is always stiffly fought. TENET in South Africa provides some insight into this issue where under the new GEN2 agreement signed by TENET and Telkom South Africa, a key obligation of the benefiting institutions (GEN2 institutions) is “to ensure that Telkom’s monthly revenue does not decline” and that any bandwidth price reductions “would be matched by compensating upgrade orders.”⁴⁸
- In other countries, the educational sector as a whole comprises a large customer base for commercial ISPs. Any attempt to establish an independent provider and cut off this revenue base will be challenged. Therefore, NRENs connecting the wider educational sector including schools will probably face a tougher challenge from private providers.

Accusations of competition can to a large extent be avoided or tempered by enacting and enforcing “acceptable use and acceptable users” policies and regulations. Privately owned commercial providers will hesitate to take on a “public good” closed network serving the education and research sector. However, these private providers must be convinced that the network is strictly for the education and research sector. In my southern Africa experience, the incumbent telecommunications services provider insisted that all schools and educational institutions had to sign a clear acceptable use policy if they were connected by the proposed educational ISP and that the policy had to make clear that resale of capacity was prohibited. Obviously restricting any resale of capacity can hinder sustainability strategies such as providing internet services to the community in the evenings or weekends or operating a public Internet cafe.

The issue of competition, as the SERENATE report acknowledges, is a difficult one to prescribe precise solutions to, and will be handled differently, in different countries. In some countries, it is not and will not be an issue. In others, there will be outright rejection of the NREN. Whatever the situation, it is important to follow South Africa’s TENET’s

⁴⁷ See <http://www.kenet.or.ke/members/index.php?yah=benefits>

⁴⁸ See “The GEN2 agreement” section of the TENET home page, <http://tenet.ac.za/>

advice⁴⁹: “It is important to maintain good relations with the Internet services industry generally and with ISPs in particular”. In its case, TENET sought and was granted honorary membership of the ISP association and it also invites the ISP association to nominate a suitable person to its Board. This is something that other African NRENs might seek to consider doing.

3.3 Scale

NRENs are often created to leverage economies of scale or to share an expensive resource to achieve an economic advantage as well as to realize a functional need. Leveraging economies of scale requires that there be “large scale”. In the case of Internet access, this requires that there are many institutions connected and a large enough aggregate demand to actually lower costs. The more institutions there are, the lower the cost per institution and the higher the negotiating strength of the NREN. In fact, NRENs seem to thrive where they can muster large scale.

It seems that NRENs find it hard to take off in countries where there is no large scale (a small population and/or a small number of universities and research institutions) or in less developed countries where institutions are poorly funded and because of the large expense involved in rolling out expensive infrastructure. Unfortunately, a large number of African countries are less economically developed and have a few universities. Could scale and its associated effects then be one of the key factors hindering the development of NRENs in some African countries? This is highly probable. Almost all the African countries where an NREN has successfully taken off seem to have at least 10 plus university-level institutions connected. For example South Africa’s TENET acts “as the appointed agent of more than 50 higher education, research and associated institutions”⁵⁰, KENET connects all 6 public and 10 private universities plus other higher education and research institutions (currently has about 51 members)⁵¹, Morocco’s MARWAN connects 13 universities, Egypt’s EUN connects at least 12 universities and Algeria’s CERIST connects 40 institutions⁵².

The effects of scale and how to counter them are discussed in the next section.

3.3.1 The effect of small scale

The SERENATE report on the workshop on NREN models⁵³ notes that research networking can be more difficult and expensive in small or less developed countries because of the higher cost per institution and higher probability of dealing with a monopoly provider. These factors are explored in detail below:

⁴⁹ See “Relations with the Internet Service Provider’s Association” section of the TENET home page, <http://tenet.ac.za/>

⁵⁰ See <http://tenet.ac.za>

⁵¹ See <http://www.kenet.or.ke/members/index.php?yah=eligibility>

⁵² Morocco’s, Egypt’s and Algeria’s figures can be found in Chapter 2 of the TERENA Compendium 2006, <http://www.terena.nl/activities/compendium/>

⁵³ See SERENATE report Deliverable [D8: Report on workshop on National Research and Education Network models](#), <http://www.serenate.org/publications/>

a) Higher cost per user or per institution

In a small (small population and/or few universities) or less developed country, it is “more expensive (per user) to provide the same level of service as in larger countries” due to four factors:

- Relatively more international capacity is required. The larger the number of higher education and research institutions there are in a country, the more likely that there is a high level of local collaboration. Also, the more economically developed the country, the more likely that there will be a significant amount of local content or research facilities to share. This translates to large amounts of local traffic, possibly outweighing international traffic. In a small country with one or two universities or a less developed country with little local content one can imagine that most of the traffic will be international in nature. This often leads to NRENs in these countries being “net recipients” of traffic. This need (and therefore focus) on international capacity over local capacity perhaps explains the “airline syndrome” in Africa “where an institution in Africa links more easily to institutions outside Africa than to those within the same country or within Africa.”⁵⁴ As international capacity is likely to be more expensive than local capacity, the overall budget of the NREN will be high relative to the few institutions that make up its membership.
- Low-capacity circuits are relatively more expensive on a unit cost basis. A few institutions are likely to require a relatively small amount of bandwidth and therefore low-capacity circuits. The more capacity one purchases, the more volume discounts one can expect to receive.
- Circuits of the same capacity are often more expensive in a small or less developed country because smaller countries are likely to have less competitive markets or monopoly providers.
- The NREN needs to put in the same amount of effort to introduce a new service as its much bigger counterpart in a large country

b) Higher probability of dealing with a monopolistic provider

Small or less developed countries with limited size markets are likely to have “de facto monopoly” providers and the regulator “may not be well equipped.” In these countries, the universities and research institutions are likely to be some of the largest customers of the monopoly provider and therefore the provider will fight, sometimes aggressively, any attempts to reduce or erode their revenue base. The provider will perceive the NREN as a danger and a threat to their monopoly privileges and is unlikely to “hesitate to threaten legal action against the NREN or the telecommunications regulator.”⁵² Having a monopoly provider also means that the NREN is restricted in the choice of available infrastructure providers and the lack of competition is likely to mean that prices for telecommunications services will be very high.

⁵⁴ From Tusubira, F.F and Mulira, N.K, 2005, Report on the proposed role of the AAU: enabling member and associated institutions to access more bandwidth at lower cost. The authors conclude that this syndrome “tends to blind many stakeholders to the real challenge: intra-African connectivity.”

3.3.2 The advantages of large scale

The most obvious advantage of large scale is lower cost per institution. There are other advantages of large scale that are not directly related to low cost per institution. They include:

- Reason would have it that the more institutions there are suffering the brunt of high prices, low bandwidth and poor service, the higher the chances that the institutions will put aside their usually rivalries and join forces to aggregate their bandwidth demands.
- The more institutions there are able to speak with “one voice”, the more influence they will exert and the more likely they will be successful at attracting government funding for NRENs and other collaborative ventures.
- Even where government funding is not available, the more institutions there are, the more likely those members are able to raise sufficient funds to create and sustain an NREN.
- . The more institutions there are, the less likely that any single institution dominates the others. A single institution dominating an NREN can be a challenge, for example if this institutions reduces its involvement in the NREN, the NREN could falter.

Scale therefore contributes to increasing the “functional need” and the “economic advantage” that drive NREN creation.

3.3.3 Countering the effects of small scale

The most obvious remedy to the negative effects of small scale is to “enlarge the user community”. In other words, allow for institutions other than universities and research institutions. Even countries with only a handful of universities are likely to have a fair number of teacher and vocational training institutions and other post-secondary institutions. For example:

- Uganda with only 5 public universities and 12 licensed private universities has over 155 higher education institutions in total if one includes National Teachers Colleges, Technical Institutions, Colleges of Commerce, Agricultural and Forestry Institutions, Health Training Colleges, Theological Institutions, Management Institutions, Co-operative Colleges, Hotel and Tourism Institutions and other institutions.⁵⁵
- Tanzania with 11 public higher education institutions (defined as university level or professional award granting institution) has at least 17 research institutions, 46 teacher training institutions and 20 vocational training centers.⁵⁶

⁵⁵ Cremin, P.D and Hyland, A. 2006, Building North-South bridges between Higher Education Institution in Ireland and Africa, A Paper delivered on 24th March 2006 to Irish Aid Third Level Conference held at Dublin City University, quoting The Ugandan National Council for Higher Education report *The State of Higher Education* (2004)

⁵⁶ See <http://www.msthe.go.tz/admission/index.asp> for stats on universities, see

- Ghana with 6 public and 13 private universities has 9 polytechnics, 7 theological colleges, 38 teacher training institutions and 23 technical institutions⁵⁷

Granted, some of the non-university institutions are likely to be quite small and have poor ICT infrastructure; however, their total number more than makes up for their small size. Scale aside; there is another more important reason why these institutions should benefit from the NREN: it is high time that universities in Africa took a real leadership role in advancing the rest of the education sector. In fact, one could argue that a true NREN should provide service to ALL educational and research institutions including primary and secondary schools. This is the current trend in Europe and North America where NRENs are connecting all educational institutions including schools as well as other social-sector institutions like hospitals. It would therefore be counter productive to limit the membership of the NREN to only universities and higher education institutions that provide university-level education when creating an NREN. In many countries in Africa, the reality is that scale, and therefore the feasibility of developing an NREN, may only be achieved if universities join arms with teacher training colleges, vocational institutions and even secondary and primary schools.

Other ways of reducing the effect of small scale as advanced by the SERENATE report include:

- Foster a good relationship with the monopoly telecommunications provider in order to successfully negotiate for lower costs
- Lobby for deregulation of the telecommunications market to allow for competition
- Try to obtain more money from the government and donors.

3.3.4 Approach to collaboration with other education sectors

Where the NREN is opened up to the entire higher education (post secondary) sector or even the entire education sector, the telecommunications network can be designed with “virtual networks” to serve specific sectors. . For instance, the virtual network serving universities may be of much higher capacity than those serving other sectors. This lends the advantage of tailoring services and applications for each sector while still leveraging collective purchasing and organizational power.

NRENs under consideration in some countries like Nigeria, Tanzania, Ghana, Uganda, Rwanda and Namibia would probably do well to partner with other non-university higher education institutions or even the entire sector. This is because some of the non-university higher education institutions are already organized or have active collaborative

http://www.msthe.go.tz/Ministry_institutions.asp for stats on research institutions, See

<http://www.moe.go.tz/ted/ted.html> for stats on teacher training colleges and see

<http://www.moe.go.tz/statistics.html>, nation 2006 statistics

⁵⁷ <http://www.edughana.net/search.htm>

initiatives underway to address issues of connectivity and content. For example, teacher training colleges are already organized and collaborating to address issues of connectivity in Uganda (under the CONNECT-ED)⁵⁸ and Tanzania (under the ICT-Connect-TED project).⁵⁹ Also Uganda (World Links)⁶⁰ and Namibia (XNET)⁶¹ have successful collaborative connectivity projects for secondary and primary schools. In these and other countries with existing collaborative initiatives within other education sectors, there are ready made opportunities at least at two levels that, I dare say, NRENs can not afford to miss:

- NRENs can increase their bandwidth purchases significantly by positioning themselves to serve these already organized institutions without incurring any significant overheads. For example, where teaching training institutions are already organized under a single entity, the NREN need only deal with that one single entity or where secondary schools are already served by an active SchoolNet organization, the NREN will only have to deal with the SchoolNet organization. The elegance of this approach is that the NREN does not have to deal with hundreds or even thousands of institutions (the basic education and teacher training sectors often have many more institutions than the higher education sector); instead the NREN deals with a few of their representative networking entities (mini NREN like networks) while benefiting from significantly increased scale.
- Most of the initiatives in the non-university sectors have a lot of political support and have already been positioned as “national initiatives”. If NRENs position themselves to collaborate with these already organized sectors, then the NREN will find it easier to build or expand its political support and possibly even attract more funding

Despite these opportunities and advantages in collaborating with the other sectors, at the end of the day, each NREN will have to carefully review the situation in each of their countries to arrive at a well informed decision before rejecting or accepting wider collaboration. Also, collaboration with other education sectors works best where the other sectors are already organized.

Finally, there is absolutely no reason why collaboration should not extend to other social sectors. In fact, NRENs in Africa could do very well to review and follow the networking activities of other social sectors if only to avoid duplication of efforts (for example in building infrastructure). Many African countries now have a number of “e” initiatives that in many cases aim at developing various NREN-like networks such as GOVNET (e-government network), FARMNET or AGRINET (farmer’s or agricultural network), HEALTHNET (for the health sector) and BIZNET (for the small business community)! Also chances are high that many a university or higher education institution like a teacher training college is likely to be located in an urban or semi urban area within a few miles or even meters of a local government office, an agricultural

⁵⁸ <http://dot-edu.edc.org/projects/ugandaConnectEDfacts.htm>

⁵⁹ <http://www.iicd.org/projects/articles/iicdprojects.2004-11-12.6571234687>

⁶⁰ <http://www.schoolnetuganda.sc.ug/homepage.php?option=vsatproject>

⁶¹

<http://sangonet.org.za/thetha/images/doc/xnet%20ict%20%20and%20cso%20presentation%2020060713v2.ppt>

extension or advisory office, a hospital or health center and several small businesses. If one were to leverage these initiatives to share infrastructure and services, one can imagine the tremendous savings that could be made and even the added negotiating power that could be achieved through this convergence of networking initiatives.

3.4 NRENs as National Initiatives

Universities in Africa frequently identify lack of awareness at the government and political level as one of the key challenges they face in introducing and expanding ICT resources. Despite this acknowledgement, there seems to be little evidence that many universities are actually actively trying to build this awareness and create buy-in. Unless concerted effort is taken to raise this awareness and to advertise the benefits of NRENs, their creation and the wider adoption of ICTs is likely to be a slow, painful and expensive affair.

The benefits of NRENs to their member institutions and to society as a whole have been explored in section 2.6. This contribution to society is a case that NRENs will have to make and by so doing will be more likely to attract public or government funding as well as other support (such as overcoming regulatory hurdles). In order for this to happen, NRENs must be positioned as national initiatives and not simply as “closed university-only initiatives” or as “exclusive clubs” for university-level and research institutions. Positioning NRENs as national initiatives means that NRENs should actively engage and involve government at a variety of levels to obtain political buy-in, funding and other support.

3.4.1 Important government stakeholders

Government at different levels should be considered a critical stakeholder for NRENs. The most important levels or government bodies to engage include:

- The council for higher education

Most countries have a council or body that is directly responsible for advising government on higher education matters. This council or body is also usually in charge of accrediting or licensing higher education institutions and in setting and monitoring quality standards for the higher education sector. This council or body can greatly influence the support an NREN receives from government by advocating for the creation or funding of the NREN. In some countries, such bodies also have some funding available that they can directly contribute to the NREN.

- The council or body responsible for research

Some countries have dedicated public organizations or government departments to oversee, advise on and set the national research agenda. Support from these bodies is crucial for NREN development. In Europe and North America, these bodies responsible for research have often provided the seed funding for NREN development.

- The ministry or department directly responsible for the (higher) education sector.

It is vital that this ministry or department buy into the NREN concept and its attendant benefits as it is the “line” ministry or department and therefore is responsible for allocation of funds to the education sector. Pay particular attention to a possible challenge to achieving scale: the fragmentation of the education system between “higher” education and “basic” education at the political level through the existence of separate ministries for these two sectors. The result of this fragmentation could lead to duplication of efforts in the higher education and basic education sector. In cases where the two sectors collaborate on an NREN, there could be challenges in trying to determine which ministry has overall control (and therefore provides most of the funding) especially where the higher education sector has very few institutions.

- The ministry or department responsible for telecommunications

The telecommunications ministry is particularly important as it is responsible for enacting overall telecommunications policy and for planning and (directly or indirectly) building the national infrastructure. It goes without saying that national policy can make, if it is supportive, or break, if it is not supportive, the creation of an NREN,. For example, if the policy prohibits the use of private VSAT systems and the country has no submarine fiber cable access or if the policy promotes a monopoly national infrastructure provider, then the NREN could face severe challenges in trying to reduce international as well as national bandwidth costs. The telecommunications ministry also usually controls the “Universal Access Fund,” where it exists. NRENs should be positioned as natural recipients deserving of such funds which can be used to build and extend infrastructure. Finally this ministry or department usually oversees or has significant influence over the telecommunications regulator.

- The telecommunications regulator

The telecommunications regulator is responsible for overseeing and implementing telecommunications policy and for granting critical licenses such as ISP and VSAT licenses. Naturally, such bodies should be sympathetic to and support the NREN.

- The ministry or department in charge of finance

This ministry or department of finance holds the national purse. More importantly, the finance ministry has a lot of influence over donor funding and its allocation. This is more so in countries that have moved to a “direct budget support model” of donor financing away from the traditional “project financing model”. Institutions wishing to tap into this type of (usually large) donor funding should ensure that the NREN initiative is identified in the national Poverty Reduction Strategy Plan (PRSP) and other such national development plans. Some donor institutions go as far as to say that if it is not in the PRSP or equivalent national development plan, then it can not be financed.

- The prime minister’s or executive president’s office

The top political leadership usually has clout and can influence other ministries or departments. Interest from the top leadership in the development of the NREN is possibly one of the surest ways to ensure access to continued public funding and other support.

- National Parliament

Parliament enacts and approves the country’s laws and regulations. If the NREN could be created or supported by an act of parliament, then the NREN would most likely be

guaranteed of long term government funding and would also be in a strong position to tap into a larger pool of donor funds.

How “far” up the government ladder one needs to go to obtain buy-in and how to position the NREN as a national initiative will depend on the prevailing local conditions. One must judge where the necessary influence, support and funding in the government lies. Positioning the NREN as a national initiative also means involving other sectors such as the private sector, which is important to obtain the buy in of the infrastructure providers and to obtain additional funding.

3.4.2 Strategies to position NREN as national initiatives

How can one turn the NREN into a national initiative? A few approaches to begin the process are provided here, but note that whatever approach is taken will have to consider the local context and conditions of each country. Example approaches include:

a) Create a national inclusive advisory committee

The potential members of the NREN should try and create a national “advisory committee” or task force during the conception, design and development of the NREN which is representative of all parties (or stakeholders) which could potential impact the NREN. These stakeholders include government ministries and departments, representatives from the different education sectors, NGOs interesting in education and research networking, donors and the private sector. Naturally, such an advisory group would not meet regularly as it is likely to be very large and would likely (or be encouraged to) elect a smaller “committee” to monitor the day to day activities of the NREN development on behalf of the larger group. The important thing is that this sort of approach makes it easier to raise awareness, makes various stakeholders feel included, and makes it more likely that the NREN will be upheld as a national initiative.

b) Hold targeted meetings with key stakeholders

Hold carefully structured “consultative” or “briefing” meetings and workshops with the relevant ministries, government departments, major higher education institutions, telecommunications infrastructure providers, private sector entities involved in ICTs in education and even key donors. A small group made up of representatives of potential NREN members should be elected to undertake this consultation. This consultation serves to raise awareness and solicit feedback which can be invaluable and create buy-in.

c) Lobby for a dedicated central budget for the NREN

Lobby the relevant line ministry or department to consider a distinct budget line for the NREN, however small. This requires considerable lobbying of the relevant units of the ministry including the planning and budgeting office! The most important consideration is not how large the initial budget is but that the principle is established. One can argue strongly that such a budget would benefit the entire sector. This will ensure that the NREN has direct budget support from government outside the members’ contribution.

d) Invite top leadership to launch NREN

Get the top leadership to launch the NREN. For example, Internet2 in the US was launched by former Vice President Al Gore⁶². This sort of participation at the highest political level is important to secure long term commitment and also goes a long way to generate media coverage and raising awareness. Other ways to involve the higher political levels is through leveraging their contacts and clout to “open doors”.

⁶² <http://www.cnn.com/TECH/computing/9804/14/i2/index.html>

4 ORGANIZATION, MANAGEMENT AND FUNDING

4.1 *Starting up, organization and management*

If a country has no NREN, how and where should they start? What shape should the management of the NREN take, what should staffing look like and what are some of the key success factors for the NREN? This section attempts to answer these questions.

4.1.1 In the beginning ...

There was a small band of dedicated individuals and a donor or government funding agency. Thus begins the story of most NRENs.

This small band of dedicated individuals can be considered to be “agitators,” “catalysts,” “champions” or “agents of influence” critical for NREN development. They have the vision, desire, determination and dedication to fostering academic and research networking and collaboration. They could be external to or part of the academic and research community in the country. The external agents could be staff of donor agencies, government bodies, NGOs or other external entity such as a foreign academic or research institution. The effect of these agents on NREN creation is explored in some detail below.

The external agents usually act as “impartial catalysts or facilitators” or more generally as “honest brokers” in any collaborative venture especially one where rivalries (however trivial or unspoken) exist among education and research institutions. Moreover, institutions irrespective of whether they are academic, public (government) or private enterprises are more likely to listen to and heed the advice of an external, independent party or “outsider” than one of their own. Perhaps this has to do with the fact that external parties are seen as impartial without vested interests. Whatever the reasons, this is an important consideration for those striving to create or stimulate the creation of NRENs.

It goes without saying that NRENs only succeed where there are internal champions who understand the local environment and more importantly can tap into personal, informal and formal or official networks to raise awareness and convince people to collaborate towards a common good. Such champions include highly respected academics, researchers and heads of academic and research institutions. Aside from bringing people together, the internal champions play two other important roles:

- a) Developing initial concept documents and funding proposals for the NREN which are required to attract support and funding.
- b) In the absence (and I would argue that even in spite of) of external donor or government funding, these influential local actors can convince the institutions themselves to part with their own internal funds to start the NREN. It is unrealistic to expect that every country should count on external funding to create an NREN. Sometimes, charity begins at home! If donors and the government see how successful the NREN is they could be more willing to invest money to expand and improve the NREN.

4.1.2 Steps to creating an NREN

The FRENIA announcement and call for proposals⁶³ acknowledges that there is no “standard formula” for NREN creation and provides a very informative view, which tallies with my own experience, of how NRENs commonly emerge. They share a number of steps to follow which are well worth repeating here:

- NRENs depend on “an initial exercise of leadership, at the most senior level of founding institutions, in agreeing to collaborate” and that such agreement should be recorded in a Memorandum of Understanding or MoU.
- The founding members should “establish a task team with definite resources and a definite mandate.”
- The founding members should “form an operational vehicle of some sort (often a non profit company or other non-governmental legal entity)” to focus on and oversee the creation and operational activities of the NREN.
- And that the established task force or operational vehicle should then “negotiate with both suppliers and customers with a view to building a network and offering a set of network services”.

As the FRENIA folks recommend, probably the first and most important step is sensitize, consult and “convert” the top leadership of the potential member institutions to the NREN cause. Other entities to sensitize and consult in this early or initial phase include the local associations of universities, polytechnics, teacher training colleges and the National Council for Higher Education (or such similar body) and the national body for research.

The founding and potential institutions and other stakeholder bodies should then be invited to a meeting where they should elect or appoint a small representative committee or taskforce to further conceptualize, promote and fully develop the NREN.

It is important that such a committee or taskforce be composed of respected, un-impeachable and well regarded representatives with a demonstrated track record of achievement. In fact, one can determine whether the NREN venture will be successful right at the onset from the caliber of elected or appointed committee members! This small committee is then responsible for “selling” the NREN to the government, donor agencies, telecommunications services providers and other actors and for generally delivering the NREN.

A last word on the FRENIA program: the program seeks to assist NREN development efforts in undertaking strategic planning activities, in obtaining skilled short term people through secondments, in negotiating contracts or other legal agreements, in providing

⁶³ See <http://tenet.ac.za/frenia/>

training and in general capacity building. This is an opportunity that emerging NRENs in Africa can not afford to miss.

4.1.3 Legal form

On the legal front, NRENs are often either independent not-for-profit entities (e.g. NGOs, Foundations, Trusts, Associations) or semi autonomous government run and owned bodies (e.g. as a department in a government ministry). The European TERENA compendium⁶⁴, the annual European NREN survey reveals that most European NRENs are independent not-for-profit entities while a few are government owned. And that the independent NRENs are separate legal entities owned and controlled by the academic and research community usually with government funding⁶⁵. Other examples of independent not-for-profit NRENs include the US' Internet2, UK's UKERNA, Canada's CANARIE, Australia's AARNET, Kenya's KENET and South Africa's TENET. This independent not-for-profit entity will serve as the "operational vehicle" for the NREN.

Independent ownership is likely a more attractive option for NRENs because independence spells a) freedom to operate and respond to changes nimbly, b) higher chances of being customer-centered and operating as a business meaning more accountability, c) ability to negotiate and sign contracts directly and more speedily and d) sometimes ability to attract diverse ranges of funding.

Government ownership and management, on the other hand, has only one major advantage: ability to attract long term government (and donor) funding. However, there is no reason why independent NRENs can not attract long term government support especially if they are positioned as national initiatives contributing to overall economic development.

The independent or even government owned NREN entity is often governed by an independent "board of directors" or "board of trustees" usually composed of representatives of member educational and research institutions, government departments or ministries (usually those responsible for education, science, technology and telecommunications) and the private industry. Its operations are in turn guided by a charter, constitution, articles of association or other governing statutes.

In creating the independent NREN entity as the operational vehicle, it is important that its constitution or other governing statutes be focused on the core NREN needs and at the same time be forward look and unrestrictive. Restrictive clauses that can be a major impediment in the future include limiting NREN membership and customers to "degree-granting" institutions only, limiting the ability of the NREN to own or lease long term assets such as fiber links or limiting the types of services the NREN can offer.

⁶⁴ See <http://www.terena.nl/activities/compendium/>

⁶⁵ Most NRENs in Europe are separate legal entities- see <http://www.terena.nl/activities/compendium/2005/Chapter%201.pdf> -and so is Internet2 in the US and CANARIE in Canada. In almost all cases, the NREN is funded (largely) by the government

4.1.4 Management

Once the NREN (whatever form the “operational vehicle” takes) is established, it is important to recruit a seasoned and proven manager and/or management team at the earliest. It pays to have a dedicated full time person to follow up and manage the development and set up of the NREN. The business of developing and running an NREN requires management and business skills such as contract negotiation, strategic planning, policy formulation, project management and financial planning as well as a general understanding of the technical issues involved. NREN founding members should not simply select a manager based on academic standing but rather on proven leadership and management record preferably in managing complex ICT programs or projects.

Board directors should also be selected on the basis of their experience and contacts that are directly beneficial to the NREN, in other words, on what they are able to offer the NREN. As Leatt and Duncan argue, the board should be an expert rather than a representative one⁶⁶. They further argue that the board must be fully empowered by the NREN members and have full authority to manage the affairs of the NREN. The board of directors and not the NREN members should oversee the management of the NREN.

Finally, NRENs should probably not be tempted to form a “collaborative committee of managers drawn from the participating institutions” in lieu of an independent board as argued by Leatt and Martin. This is a likely recipe for trouble on account of the likely conflict of interest arising from fusion of the role of provider and customer, explored below, and on the “paralysis that it can engender through the eternal threat of veto of one”.

4.1.5 Separation of provider and customers roles

Leatt and Duncan provide very enlightening insight into the subject of “providers” vs. “customers” roles. This is an extremely important distinction and I raise it here prominently because of my own experiences and because it is very likely to become a real issue in the process of creating NRENs in Africa.

The NREN is and should be positioned as a service provider. The institutions on the other hand must be positioned as customers. These roles should be clearly distinct, understood by the parties, adhered to and enforced say through signing a formal contract between NREN, as service provider, and participating institution, as customer. Separation of these roles has the benefit of making sure that the NREN can make tough decisions for the benefit of all, is accountable and responsive to its customers’ needs and provides quality service.

The NREN as a service provider can not therefore be run or managed by heads of IT or other departments of the member institutions because they are also customers and would create potential conflicts of interests. Where there is a shortage of skilled staff to run the NREN, secondments from member institutions could be attempted. However, any seconded staff must be willing to completely forego their roles at or preferably should

⁶⁶ See, Leatt, J.V and Martin, D.H 2000, Reflections on collaboration within SA Higher Education by two bloodied but unbowed participants, <http://tenet.ac.za/>

resign from their parent institutions to enforce the separation of provider from customer roles.

Leatt and Duncan discuss several other principles of cooperation for a successful collaborative venture and it is strongly recommended that anybody considering setting up an NREN should read this paper.

4.1.6 Staffing

NRENs need dedicated staff who can focus all their energies on getting the NREN created, on reviewing infrastructure needs and options, on acquiring or leasing the necessary infrastructure, on operating and maintaining the telecommunications systems, on supporting users and on providing additional services as may be required by the user community. Running an NREN is a full time affair and can not be achieved with part time staff seconded from member institutions. The member institutions coming together to create an NREN or the government or donor funding entity must be prepared to provide for dedicated staff right from the start. These may be seconded from member institutions or the funding agency but it is highly advised that NREN staff be independent from either member institutions or funding agencies. This will ensure that their real or perceived interests are the creation and operation of the NREN and not biased towards any institution's interests.

It is obvious that NRENs are going to need technical staff to operate and maintain the telecommunications infrastructure and systems. What is less obvious is that NRENs also need seasoned and proven managerial and administrative (financial or accounting) staff. The managerial staff will negotiate complex contracts, set policy, write funding proposals and liaise with the member institutions and the wider internet industry while the administrative staff will undertake billing, collection, general accounting and book keeping. The precise number of staff required will depend on the particular NREN, the number of members, the ownership model for the infrastructure, the types of services offered and how large the network is.

The most comprehensive source of NREN staffing is the TERENA compendium⁶⁷. According to this report, the average number of full time equivalent staff of an NREN in the European Union (EU) area is about 39 people of which on average 9 people are outsourced contractors. The percentage of total staff that is considered to be technical staff is about 69%. On the other hand, the average number of staff in the middle income non EU countries of eastern Europe and the Mediterranean region is about 20 of which on average 4 are outsourced. The percentage of total staff that is considered to be technical staff is about 63%.

NRENs in the EU area are highly developed and this level of staffing is probably not something that emerging NRENs in Africa can hope to justify or sustain. A more telling figure is probably that of staffing levels of the non EU countries of Eastern Europe and

⁶⁷ See Chapter 6 of TERENA compendium 2005, <http://www.terena.nl/activities/compendium/>

the Mediterranean region and even then this could probably not be achieved until the NRENs are fully up and running and serving several tens or hundred of institutions.

Of particular interest to African NRENs might be the staffing levels of NRENs of Algeria and Morocco given in the compendium. These countries' NRENs have 27 and 6 staff respectively with no outsourced staff and a technical staff complement of 67% and 68% respectively. However, Algeria's CERIST connects 40 institutions while Morocco's MARWAN connects 13 universities suggesting (not surprisingly) that the number of staff will depend on the number of connected institutions and the types of services offered by the NREN. Therefore, African NRENs are going to have to consider their staffing needs carefully taking into consideration their local conditions and types and numbers of potential members.

4.2 Funding

There are three main sources of NREN funding: Government, Donors and NREN member institutions. Government funding is usually provided through one or more ministries, departments or other such bodies responsible for education, science, technology, telecommunications or research. Donor funding includes funding from bi-lateral and multi-lateral development organization, public and private foundations, Non Governmental Organizations (NGOs) and private industry. Member institutions contribute to funding mainly through payment of fees for services received. Many NRENs seem to benefit from both government and donor funding (mostly external funding) and member fees. In turn, external funding and member fees usually play two different roles.

4.2.1 Government and Donor funding

Government and donor funding seems to be critical in the initial phase of establishing the NREN and acquiring the physical network. After the initial phase, this funding is also required to continuously upgrade and extend the physical network and develop new services.

The reason for the importance of government and donor (especially external) funding in the initial phase can be found in Leatt and Martin's paper⁶⁸, when discussing Joseph A. Boisse's postulates about library cooperation. They opine that "collaboration is easier to launch with somebody else's money". They further argue that external (donor) funding is necessary not only to finance the "deployment of new infrastructure" but also for the "pre-start up costs of getting collaborative ventures properly conceived and structured". Pre-start up activities include assisting the educational and research institutions "in establishing a strong and knowledgeable team⁶⁹" such as that required to negotiate better rates with telecommunications providers and other service providers. In general, donor and government funding act as a catalyst to NREN creation.

⁶⁸ Leatt, J.V and Martin, D.H 2000, Reflections on collaboration within SA Higher Education by two bloodied but unbowed participants

⁶⁹ See also the TENET story in <http://www.foundation-partnership.org/linchpin/profiles.php>

In sub-Saharan Africa, NREN creation (both the organization set up and the physical network infrastructure or capacity acquisition) has benefited from donor funding. In the initial phases, TENET in South Africa benefited from funding from the Mellon Foundation and the fore-runner UNINET relied on funding from the South African government's Foundation for Research Development (FDR).⁷⁰ KENET initially benefited from funding from USAID for its initial development⁷¹.

When governments and donors fund NRENs, the funds may be disbursed directly to the NREN (central funding) or channeled through the NREN member institutions. The SERENATE summary report⁷² discusses the advantages and disadvantages of central funding vs. funding through member institutions. In general, central funding is most appropriate in three cases:

- a) During start up phase when NREN needs to make decisions quickly
- b) In economically less developed countries where institutions are generally financially constrained and NREN funding, if channeled through the institutions would compete with other equally important activities
- c) For “testing of new technologies and the development of new services that are for the long-term benefit of users in general, but bring no direct short-term return to individual connected institutions.”

Conversely, funding through member institutions (usually on the basis of capacity, usage or both) “provides a strong incentive to NRENs to keep adapting the services that they offer to the actual needs of users.”

Most countries use a mix of central funding and funding through member institutions and which method countries use in Africa will depend on their own local circumstances.

4.2.2 Member fees

Member fees, on the other hand, are critical for running and sustaining the NREN. These fees come in the form of annual contributions or “membership fees” and payments for services provided such as internet access and usually come from the institution's own budgets. Interestingly, where NRENs do not build dedicated networks but instead lease capacity from existing providers (i.e. no high capital or start up costs), the NRENs are likely to be largely funded from member fees. Sometimes, member fees are seen as “indirect” government contributions since most universities and research institutions are likely to be government funded.

⁷⁰ See <http://www.foundation-partnership.org/linchpin/profiles.php> and <http://tenet.ac.za/Publications/ReflectionsOnCollaboration.pdf>

⁷¹ See <http://www.kenet.or.ke/about/index.php?yah=history>

⁷² See SERENATE report Deliverable D21: [Summary report on the SERENATE studies](http://www.serenate.org/publications/d21-serenate.pdf), <http://www.serenate.org/publications/d21-serenate.pdf>

It is difficult to say to what extent NRENs thrive on member fees; what is clear is that these member fees are a critical life line of NRENs. Reviewing the TERENA compendium which has one of the most detailed analysis of NREN funding in the EU area, Eastern Europe and the Mediterranean region reveals that on average NRENs obtain about 36% of their income from member fees⁷³. However, this varies widely from NRENs that rely 100% on member fees to those that are fully funded by government.

In sub-Saharan Africa, NRENs seem to survive largely on member fees even though the initial funding to set up the NREN might come from donors. That's probably because most NRENs are not national initiatives in the sense that they were established or supported by government but rather are member institutions' initiatives. Another reason might be that donors are often willing to provide one-time funding for capital-type expenses but are unwilling to fund running or operational costs.

There are both advantages and disadvantages to NRENs relying on member fees for the larger share of the budgets. The most obvious advantage is that NRENs can be more accountable to and provide high quality and relevant services to their members. The downside of course is that member institutions especially in Africa are generally poorly funded and unable to contribute the kind of sums required to build and extend infrastructure or provide more capacity.

4.2.3 NREN expenses

From a review of various sources and particularly the TERENA compendium,⁷⁴ there appears to be 3 main expenses for NRENs:

- Capacity costs- this includes the cost of leasing infrastructure and purchasing capacity
- Equipment costs- this includes the cost of providing transmission equipment, switches and routers and any servers for applications such as billing and monitoring
- Salaries- this includes all salaries and benefits of the NRENs staff

NRENs will usually also have other expenses such as:

- Legal costs- for setting up and registering the NREN and for drafting and reviewing contracts and policies.
- Rent and utilities costs

4.2.4 Sample NREN infrastructure and operating costs

It is extremely difficult to determine how much the infrastructure (equipment) and general operating costs for NRENs will be. A good start for developing NRENs in Africa is probably the European SERENATE report discussing funding of European NRENs⁷⁵. From this report, sample and approximate costs can be obtained, mainly related to fiber based networks in the EU and these can be taken as indicative costs:

⁷³ See Chapter 6 of TERENA compendium 2005, <http://www.terena.nl/activities/compendium/>

⁷⁴ See chapter 6 of the TERENA compendium 2005 at <http://www.terena.nl/activities/compendium/>

⁷⁵ See SERENATE report deliverable [D14: Report discussing future scenarios for the funding of network infrastructure in the European research networking community, and of related costs](http://www.serenate.org/publications/d14-serenate.pdf), <http://www.serenate.org/publications/d14-serenate.pdf>

- Cost of laying own fiber- 50,000 Euro per km
- Cost of leasing dark fiber (average EU)- 500 Euro per km, 750 Euro per km (with amplification) and 1,000 Euro per km (with regeneration) per year
- Operation and maintenance of fiber- 1,000 Euro per km per year
- Operation and maintenance of transmission equipment- 20% of investment costs of equipment

The SARUA report⁷⁶ also has a few indicative costs which are informative:

- Cost of laying fiber on existing electricity poles- US\$2,000 per km
- Cost of laying fiber on own pole line- US\$10,000 per km
- Cost of buried fiber in a duct- US\$30,000 per km

These are only *indicative* and should be taken in context.

4.2.5 The question of sustainability

It is now the norm that donors will fund projects such as NRENs provided that they can demonstrate financial sustainability in the short term. The expectation is usually that member fees should cover all running and operational costs. This expectation is often unrealistic for a number of reasons:

- NREN's operating costs include significant costs for equipment and infrastructure upgrade which are extremely high and beyond the ability of members to finance themselves
- As I have noted above, member institutions require advanced network services that commercial providers are not willing to provide to such a community perceived to be relatively small and with low purchasing power.

The solution then is to position NRENs to receive long term funding. This sort of long term funding can only be obtained from national governments (or donors acting through national governments). As the SERENATE summary report⁷⁷ strongly recommends, *“national governments should be aware that research and education networking in their country, and in particular their NREN, is an asset for economic growth and prosperity. It is a source of innovation and provides fast and widespread technology transfer to society and industry. Promoting such technology transfer should be an explicit goal of NRENs”*. In other words, the NREN should be funded as a “public good,” as a core part of the overall strategy for economic development and poverty reduction. This in turn requires that NRENs position themselves as “national initiatives” as discussed more fully in section 3.4.

However, this is not to say that NRENs should not charge their members for services offered. In fact, NRENs should not try to obtain all their funding from other sources. Charging member fees ensures that the NREN stays responsive to the members needs. Further, it is inconceivable that any NREN is ever going to have enough government or

⁷⁶ See page 28 of the SARUA report at <http://www.ubuntunet.net/documents/Sarua-fibre-final-report-draft-2006-03-04.pdf>

⁷⁷ See SERENATE report Deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/), <http://www.serenate.org/publications/>

donor funding. Rather, member fees should be considered as an integral strategy for raising funds and for the sustainability of the NREN.

4.3

5 Looking ahead

African universities, and indeed the entire African higher education sector, ought to claim their rightful place at the cutting edge of research for economic development. NRENs are a critical necessity for this to happen. Existing efforts to develop and expand NRENs in Africa must be applauded and supported.

In order to advance the NREN agenda, existing NRENs should consolidate and expand their activities in innovative ways. For NRENs under consideration or development (or even for existing NRENs), there is a need to obtain more information to aid intelligent discussions and strategic decision making and a need to promote NREN initiatives as truly national initiatives that benefit society as a whole. I follow up with a number of proposals specifically on how the NREN agenda could be advanced. The proposals involve conducting strategic studies and targeted workshops. I hope that existing or planned initiatives focusing on promoting African NREN development will pick up on these proposals and include them in their own plans.

5.1 Existing NRENs: What next?

What next for NRENs in Africa that already exist or have just been launched? This section explores some activities and strategies that they may want to undertake to provide more or higher level services or to increase efficiency and effectiveness if they haven't already.

5.1.1 Consolidate

Existing NRENs should be seeking to consolidate their current efforts through provision of additional services and applications to their members. Some additional services to offer include:

a) Bandwidth management

A lot of precious bandwidth resources are “wasted” or “eaten up” by useless traffic including viruses, worms and peer-to-peer multimedia sharing applications. At the institutional level, the lack of bandwidth management has less to do with funding and possibly more to do with lack of skilled human resource capacity. In fact most bandwidth management strategies can be implemented with very low outlays of new funding.

NRENs can provide centralized training, capacity building and advisory services to their member institutions to improve bandwidth management. NRENs should also undertake bandwidth management on the national and international networks they manage. An excellent report on bandwidth management strategies and techniques is “How To Accelerate Your Internet: A practical guide to Bandwidth Management and Optimisation using Open Source Software” edited by Robert Flickenger⁷⁸. It is highly recommended reading for NREN and Institutional IT staff.

⁷⁸ The book can be downloaded at <http://bwmo.net/>

NRENs can also offer related advisory services such as network security, intrusion detection and incidence response.

b) Support and advice to strengthen and expand local campus infrastructure

It is in the NREN's best interests to ensure that its members have good campus infrastructure as this will lead to better utilization of bandwidth, increase demand for value added services and promote the research agenda. Such support could be in the form of training, conducting site surveys and help design proper networks. NRENs could also provide "outsource services" at a fee to their member institutions. Such services might cover areas such as system administration or management of the member institutional networks' central servers and core and border routers especially for institutions with few or unskilled IT staff

c) Hosting and other data center services

There are still a number of African universities and many non-university higher education institutions without any web presence or email systems. Even where the university has a website, the site is usually poorly designed, rarely updated and often inaccessible (sites on servers at institutions with 64 kbps links can be a challenge to access!). The number of institutions, outside South Africa and North Africa that provide institutional email to students is countable. Even where this happens, the institutional email system is hardly ever used because it is unreliable or generally inaccessible because it is usually "down". That is why a majority of African academics and research still heavily rely on Hotmail, Yahoo and Gmail web mails for their correspondence. Obviously, NRENs can change this state of affairs by providing reliable, centrally managed hosting services including providing server space, web mail systems, database systems and even web page development services to their members. Other data center services that NRENs could offer include off-site backup for disaster recovery and collocation of institutional servers

d) ICT procurement

NRENs can act as agents of their member institutions in procuring other IT systems and services. For example, NRENs can help negotiate for bulk software licenses. NRENs can also provide advice and expertise in general IT procurement, for instance, by helping member institutions develop technical specifications or write tender documents.

On the application front, NRENs can provide a whole host of beneficial applications and associated services such as web development, DNS, hosting services, redundant and backup servers and email services. There is no reason why the more enterprising NRENs can not develop "data centers" and offer services at a fee to their members.

5.1.2 Expand

For NRENs with a few members or whose membership is restricted to university level institutions only, it may pay to consider expanding membership at least to the other higher education institutions. Such NRENs such carefully weigh the financial and strategic benefits against the costs (including the human resource capacity) of increasing the number of benefiting institutions.

For countries where other (non university) higher education institutions are already organized in some way, it is relatively easy and affordable for the NREN to become their service provider as it only has to deal with the (single) entity representing those other institutions while increasing its bandwidth purchases significantly. In other words, as far as the other non-university institutions are concerned, the NREN is simply another ISP albeit one with (hopefully) very competitive pricing and added-value services. Of course, every NREN should aim to move from a pure Internet and infrastructure provider to a catalyst and promoter of local institutional collaboration and collaborative research.

Expansion may also be in the form of upgrading the existing NREN network to increase capacity of the links, reviewing and changing some of the infrastructure ownership models where conditions become favorable or even renegotiating contracts with service providers to obtain more capacity or more services at same or lower cost.

5.1.3 Innovate

Lastly, existing NRENs need to innovate simply beyond providing additional capacity and internet related services such as DNS or hosting. There are a few areas where existing NRENs might look to innovate:

- **Video conference and Voice over IP:**

One can imagine the tremendous boost to collaboration and the possibilities of e-learning that would open up if universities in a country were able to hold real-time videoconference meetings with each other, with their own geographically separated campuses or with other universities else where in the world. With the price of national and international calls being prohibitive or where they are reasonable the system being unreliable, the provision of a reliable and low cost Videoconferencing over IP and Voice over IP (VOIP) systems both nationally and internationally would probably significantly contribute to national, regional and international collaboration. The reason the “airline syndrome,” discussed earlier in this paper, is probably still “entrenched” in Africa (intra-nation and inter-nation) is that there are no reliable and affordable communication systems. Applications like videoconferencing and VOIP might begin to address this problem.

- **Connections to other NRENs:**

One contribution that NRENs can make to Africa’s economic development is to open the physical and imaginary “borders” that exist between African countries and especially between higher academic institutions in different African countries. They can do this by making it easier to communication and collaborate between their respective countries and indeed all over Africa by forming linkages with other NRENs. Of course, this should extend to international NRENs as well especially those with access to expensive research facilities. This pan-African and regional (inter-nation) collaboration also requires a “super REN”- a pan African Research and Education Network and is discussed briefly in the succeeding section.

- **Building local “super high-speed” experimental (or “test bed”) networks:**

African NRENs should strive to investigate advanced networking concepts and applications both for their own use but also so that they may transfer any lessons learned

to the commercial sector. It is lamentable that after African universities pioneered the Internet in Africa, as universities did else where in the world, they have in almost all cases been displaced from the forefront of technological innovation in this sphere to the extent that African universities are now being warned that they stand to miss the technological revolution that is the Internet and its attendant benefit. This state of affairs must be righted.

- **Catalyzing research and collaboration:**

NRENs can contribute to inter-institutional collaboration and research by convening researchers, academics and students to test new systems and applications and undertaking joint research with member institutions on advanced networking concepts. NRENs can also support activities such as joint institutional content development and sharing of research results among others by providing collaborative technology platforms and tools.

5.1.4 Pan African RENs

This paper would be incomplete without some discussion of pan-African Research and Education Networks (REN). Pan-continental networks exist and are successful in Europe (GEANT), South America (CLARA) and Asia (the TIEN2 project). The existing pan-continental RENs are often owned by NRENs and they in turn support NRENs with expertise, centralized services and international connectivity to the commodity Internet and other continental RENs. More importantly, they promote regional (inter-nation) cross-border cooperation and collaborative research and development.

Some important players promoting pan-African networking are:

- UbuntuNet Alliance which has been established to act as Africa's REN and was founded by a number of existing and emerging NRENs⁷⁹.
- The Association of African Universities (AAU) which has established a Research and Education Networking Unit responding to a mandate by its member universities to coordinate and facilitate REN initiatives. The AAU also recently signed an MoU with two other important pan-African entities AfriNIC Ltd. and the African Network Operator Group (AfNOG) to further its mandate, the "ultimate goal being to build an African Research and Education Network (AfREN) which will be linked to its homologue networks in other parts of the world".⁸⁰
- The African Virtual University which is the host institution for the "Bandwidth Consortium", which is "a major collaborative project of the Partnership for Higher Education in Africa". The project leverages economies of scale to reduce the cost of satellite bandwidth by pooling the bandwidth demands of benefiting institutions⁸¹.

These are just examples of pan-African research and education networking initiatives underway. A fuller list of such initiatives including the various actors, stakeholders and donors can be found in the excellent IDRC sponsored report "Promoting African

⁷⁹See <http://www.ubuntunet.net/index.htm> for full information on UbuntuNet

⁸⁰ See AAU press release at <http://www.aau.org/announce/detail.htm?ai=52>

⁸¹ See <http://www.foundation-partnership.org/index.php?sub=pr&pr=2>

Research and Education Networking or PAREN report⁸²". The report also considers several models of pan-African RENs which is most interesting.

5.2 Undertake Strategic Studies

While there might appear to be a study or report "fatigue" in this area, the fact remains that one needs to constantly update knowledge in this field in order to inform future plans, strategies and priorities. There are also two other reasons why more focused studies might be required: i) we need more detailed and pertinent information on the environment in which NRENs operate or would be operating to inform NREN development in Africa and ii) there has been tremendous activity in the NREN development space in Africa over the last two years and we need to take stock of what has actually happened or not happened. In reviewing some of the reports on European NRENs such as the SERENATE reports and the TERENA compendium, I have come to realize that we are missing quite a bit of information that would be vital for NREN development in Africa and for advancing, in concrete ways, further discussions on NRENs in Africa. African NRENs need, in short, a concerted SERENATE-type study and a TERENA-like annual or bi annual compendium.

To this end, three focused studies are proposed:

i) A research needs analysis

Somehow, it appears that existing and planned NRENs are driven by and designed for increasing internet access bandwidth rather than by actual user needs. Clearly, this sounds like NRENs are putting the cart before the horse in some way. A study into the academic and professional research needs of the higher education sector in Africa would surely be extremely valuable for NRENs. Such a study would consider among others: a) existing research networks and other large scale collaborative efforts in Africa b) areas of research that are a priority for African institutions c) expectations of researchers on how an NREN could support their work d) how users of existing NRENs use them to support their research e) whether existing NRENs have advanced the research agenda or not and how they could be supported to advance this agenda and f) the institutional, national and international research needs of African institutions among other issues. Such a study would probably require sending out a questionnaire to hundreds of academics and researchers across Africa and perhaps holding focused feedback workshops with end-users in institutions that are currently served by or are considering developing an NREN.

ii) Feasibility or Market Study

There does not appear to be serious feasibility studies on what it would take, how much it would cost and what the implications would be or even on whether the NREN concept could work in various countries in Africa where NRENs are under consideration. Further, any serious discussions on NRENs in some such countries or a discussion of alternative models or even new innovative approaches in these countries is really impossible without having precise facts, figures and a good understanding of the situation on the ground. Hence this call for a full feasibility or market study.

⁸² See report at http://www.connectivityafrica.org/page.php?file=PAREN_Report_final.pdf

This study would build onto the SARUA dark fiber study as well as the PAREN study by considering the environment in which existing and planned NRENs would operate on a country by country basis. Such consideration would include: a) a full review of existing major telecom providers and more importantly the coverage and capacity of their current and planned infrastructure, b) a survey of all existing higher education institutions' (including teacher training colleges, vocational colleges, technical schools, polytechnics) capacities, ICT plans and state of local networks c) mapping of institutions' location in relation to existing or planned national infrastructure d) existing and planned national infrastructure projects e) an estimation of the bandwidth/ capacity requirements of institutions for the short and medium term f) a pricing survey of infrastructure development and service provision g) the state and likely effect of regulation on NREN creation and/or expansion . The result of data collected would be used to determine various feasible models for network ownership including evaluation of such options as such as buy vs. lease, optimum NREN network designs, amount of required short and medium term national (core) and international capacity, types of services that the NREN would provide and cost estimates for such network designs or ownership models (I assume NRENs would like to know what the bottom line for providing quality service would be) among other considerations.

iii) An annual or bi-annual African NREN “compendium”

It would be useful to publish an African NREN compendium similar to the TERENA compendium that seeks to track the advancement and development of NRENs in Africa. Such a compendium could build onto the efforts of the existing African Tertiary Institutions Connectivity Survey or ATICS.

5.3 Workshops or seminars

These workshops or seminars proposed are meant to raise awareness and attract support for NRENs. These workshops would probably have to be held on a national or perhaps even regional basis and it is proposed that if and when they are held (if they haven't already been held), they take advantage of other events that bring together the targeted audience. To maximize the benefit of the workshops, they would probably have to be organized as “dynamic problem solving sessions.” Important workshops to have would include:

- **Operators workshop**

This would be in form of a working session that would bring together all major operators in a country to enlighten them on the importance of NRENs and to seek solutions and support to the NREN development challenges and agenda. Such workshops could be held in collaboration with industry IT groups like AFNOG, AFRINIC and GVF. Other regional or pan-African workshops for operators could also be held by piggy backing on regional or pan-African events organized by groups like AFNOG and GVF.

- **Regulators workshops**

One critical stakeholder for the NRENs is the telecommunications regulator who must understand and support the intentions and benefits of NRENs. Working sessions with

national regulators would be critical as would sessions organized regionally to take advantage of the regional regulator associations.

- **Government stakeholders' workshops**

It is critical that NRENs raise awareness of their existence and benefits to the government and specifically to the ministries or departments in charge of education, infrastructure, ICT and finance. I would argue that NRENs need to seriously lobby these ministries and any other important national government entities critical for success or to attract funding.

5.4 Conclusion

NRENs in Europe and North America have continued to be at the forefront of and are billed to be “the most advanced part of the entire Internet”⁸³. Unfortunately, unlike elsewhere in the world, the academic and research community in Africa seems to have lost the lead in technological innovation that is driving the growth of the Internet bar perhaps for a handful of countries. However, there is hope and this situation seems to be changing slowly but surely. A few countries in Africa such as South Africa, Kenya, Malawi, Egypt and Morocco have active NRENs. Many more countries such as Uganda, Tanzania, Rwanda, Democratic Republic of Congo and Ghana are in the process of establishing NRENs. If this trend continues, NREN creation and operation in Africa (as elsewhere in the world) could have vast potential implications for the development and advancement of telecommunications. Perhaps, entertaining a little bit of wishful thinking, NREN creation in Africa will herald a new chapter in the continent’s Internet story, helping to greatly increase coverage and access to affordable connectivity while stimulating the introduction of advanced Internet applications and services.

⁸³ See SERENATE summary report, deliverable [D21: Summary report on the SERENATE studies](http://www.serenate.org/publications/d21-serenate.pdf), <http://www.serenate.org/publications/d21-serenate.pdf>