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'DAZZLING TECHNOLOGIES': ADDRESSING THE DIGITAL DIVIDE IN THE SOUTHERN AFRICAN UNIVERSITIES

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ABSTRACT: The 'digital divide' is both an infrastructural reality and a metaphor for Africa's position in the global economy. We live in an era that defines itself by the extent to which it interacts, creates and shares knowledge globally, using the network of advanced telecommunications, the Internet.

Southern African countries, their universities and research communities, are recognising that focusing purely on basic network infrastructure is inadequate to the needs of scholarly research and higher education in the 21st century. Southern African universities must acquire the means to participate effectively in global knowledge production. In particular, they must adopt and use advanced telecommunications infrastructure in the form of National Research and Education Networks or NRENs and a regional REN to connect students and researchers across national borders.

Yet the means to share knowledge is not sufficient to bring about a healthy knowledge economy. A paradigm shift has to be made from a purely technological view of the issues, to a full recognition of the interplay between technological infrastructure and the developmental and knowledge purposes to which it is put.

This article provides an overview of the emerging NREN landscape, noting developments under way that are intended to promote and facilitate excellence in scientific networking in the region. It discusses the constraints and enabling conditions for overcoming the digital divide in the Southern African higher education context. Finally, it proposes a rudimentary performance indicator framework for assessing progress.

Bandwidth, connectivity and research collaboration

The countries of Southern Africa are poorly served with respect to ICT resources and access to the Internet, resources that are sorely needed by higher education institutions in the sub-region in order to enable Southern Africa's knowledge to permeate the classrooms and other spaces where ideas for a future world are being wrought. Southern African scholars publish in a range of knowledge fields, with important contributions in the health sciences (with some specialisation in public health, tropical medicine, and infectious diseases), in the agricultural sciences, geology and earth sciences, as well as some work in the marine and space sciences (Mouton, 2007). These emerging bodies of knowledge are poorly utilised by students, scholars and researchers as they cannot easily be accessed, either in print or in electronic format. Nor do Southern African researchers participate effectively in global or regional research communities, which have come to rely on high-speed electronic networks for conducting and producing research.

Ng'ambi (2006) argues that ICT must become a centrepiece of university infrastructure – bringing free and open software and collaborative web-based teaching tools into the learning endeavour. It is argued that:

> *Bandwidth is the lifeblood of the world's knowledge economy, but it is scarcest where it is most needed - in the developing nations of Africa which require low cost communication to accelerate their socio-economic development. Few schools, libraries, universities and research centres on the continent have any internet access. For those that can afford it, their costs are usually thousands of times higher than for their counterparts in the developed*

world, and even Africa's most well-endowed centres of excellence have less broadband than a home broadband user in North America or Europe (Jensen, 2006: 2).

The November 2005 conference of the Association of African Universities (AAU) preparatory to the Tunis World Summit on the Information Society (WSIS) articulated the following objective, as presented by Pehrson & Ngwira (SARUA, 2006: 3):

No later than 2008, universities and research institutions in Southern Africa will have access to broadband services and the global Internet on the same level as peers in the developed parts of the world, with a quality of service in the Gbps rather than Kbps range, and delays, variations and error rates as defined by normal properties of properly run terrestrial fibre networks.

The objective was laudable, but was never met. The supporting role that ICTs in general and national research networks (NRENs) in particular might play in fostering the wide-scale availability of textual, audio and video resources has not yet materialised, nor has the flow of research data to the higher education community. This article considers how it might be possible to execute such a remarkable jump across the digital divide. In particular, it provides an overview of some of the main initiatives in the South African Development Community (SADC) region; and of the array of constraints and enabling conditions that exist in terms of harnessing knowledge technologies for the purposes of higher education, research development and scientific networking. It presents an evaluative framework of key performance indicators for research networks at the campus, national, regional and international levels, viewed from the perspective of universities. This framework may be used to review the success of existing and new initiatives.

The digital deficit and the future of Southern African universities

First, it is useful to situate the discussion using indicators on the nature and extent of Africa's digital deficit, and on where the impetus for an upsurge in digital capacity in Southern African universities is intended to come from. The future of Southern Africa is intertwined with the infrastructure realities of the broader continent, hence reference is made to the African context.

Africa's estimated population of some 991 million represents approximately 14% of the world total, with 67.3 million Africans or 3.9% of world population using the Internet (Internet World Stats, September 2009). Of the top ten Internet countries in Africa, two (South Africa and Zimbabwe) are in Southern Africa and these two are the only ones in the SADC region to have Internet user populations of more than a million people (ibid). Broadband penetration for the whole of Africa is lower still at around 0.1 fixed broadband subscribers per 100 inhabitants and 0.9 mobile broadband subscribers per 100 inhabitants (ITU, 2009: 2). Given that the number of Internet users in a country is an indicator of ICT adoption, that world Internet penetration is estimated at 25.6% and that broadband penetration in many developed countries is surging ahead, the digital divide as portrayed here between the African and world averages is stark indeed (Internet World Stats, 2009; Rena, 2008).

Data on increases in African Internet usage indicate very fast percentage rates of growth. While the population of global Internet users grew by 380% in the period 2000-2009, and South Asia's population of Internet users grew by 900% (Khan, Cottrell, Kalim & Ali, 2008: 10),

Africa's usage grew by 1 392% (Internet World Stats, 2009). This translates into growth of between 91% (South Africa) and 57 900% (Democratic Republic of Congo, DRC) for Southern Africa. Despite these exceptionally high rates of growth, the level of Internet penetration in 2009 was less than 10% of population in all SADC countries except the islands of Seychelles and Mauritius (ibid). In eight SADC countries, Internet penetration is below 5% and levels of 0.5 – 1.5% pertain in the DRC, Madagascar, Malawi and Tanzania. These levels (5%) are similar to those of the eight countries[1] in the South Asian region, which are nevertheless engaged in building NRENs (Khan et al, 2008). The extremely low levels of Internet penetration in the latter group of Southern African countries can be explained by virtue of the existence of very large populations in the context of very low gross national incomes per capita (AfDB, 2009), as well as the existence of weak policy and regulatory institutions for the ICT sector.

The uptake of mobile telephony in Africa (attractive for its relative accessibility and affordability) is very high; however the potential of this platform for increasing Internet penetration on the continent is limited by high costs of mobile broadband (Gillwald, 2008: 14). Several studies, including a study under the auspices of the Southern African Regional Universities Association (SARUA) have found Africa to be covered with thousands of kilometres of high-capacity optical fibre cabling, as deployed by fixed and mobile telecommunications operators and power utilities extending and upgrading the power grid (Martin, 2006b: 2-3; SARUA, 2006: 5; World Bank, 2008: 10). However, universities in the Southern African region are largely disconnected from this communications infrastructure, because of either policy or financial constraints, or both. These limitations with respect to both fixed and mobile Internet access creates a scarcity of channels available to students, academics and researchers for increasing their access to local and global knowledge.

Importantly, there appears to be a swing in top-level African political commitment towards addressing the digital divide: there is recognition that increasing access to localised broadband connectivity is essential to Africa's socio-economic development and that optical fibre networks are the best means to supply reliable high-speed international bandwidth at reasonable cost (eAfrica Commission, no date). The New Economic Partnership for Africa's Development (NEPAD) has established the NEPAD ICT Broadband Infrastructure Network Project which aims to connect all African countries to one another and, in turn, to the rest of the world through broadband fibre-optic submarine and terrestrial systems. It envisages an African broadband network that will provide abundant bandwidth, easier connectivity and reduced costs, while integrating the continent through the facilitation of trade, social and cultural exchange (ibid).

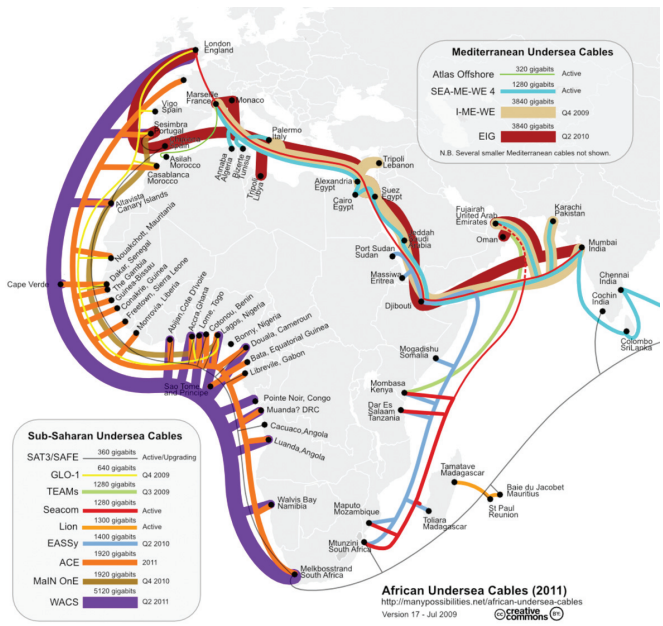
The project framework established by NEPAD for the initiative takes as its point of departure that the infrastructure should be viewed as a public good, operated on a cost-recovery basis, with non-discriminatory open access (access for all 'authorised service providers' on the same terms and conditions) and equitable joint ownership of the backbone infrastructure across the continent (eAfrica Commission, no date). In 2006, 12 Eastern and Southern African countries[2] signed the Kigali Protocol encapsulating the policy principles and details of the Special

1 Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

2 Botswana, Democratic Republic of Congo (DRC), Lesotho, Madagascar, Malawi, Mauritius, Rwanda, South Africa, Tanzania, Uganda, Zambia and Zimbabwe.

Purpose Vehicles (SPVs) that will own, operate and maintain the network[3] in these sub-regions. In addition, a broadband network for West, Central and North Africa has been agreed by NEPAD with exploratory studies and planning currently under way (ibid). The advocacy work of groups such as eGY-Africa[4] with regard to research networking has made a significant contribution to achieving this commitment (Barton et al, 2009).

There has been no shortage of private-sector activity – including partnership with the public sector – to begin providing much-needed broadband infrastructure and capacity to the region, though the current focus of activity is on the undersea cable environment represented in Map 1 below. There are three main complementary projects (EASSy, Seacom, and TEAMs[5]) that have been racing to deploy fibre along the Eastern coast of Africa. The current front-runner is Seacom, whose service went live in 2009, offering high-capacity bandwidth at significantly lower pricing levels than the satellite connectivity on which African countries have historically relied. Good progress has also been made by TEAMS, a project funded by the Kenyan government and Etisalaat (UAE) to link East Africa through the United Arab Emirates to other global connectivity systems. EASSy involves 26 telco operators and is 90% African owned, with ownership underwritten by substantial investment from development financing institutions including the European Investment Bank and the African Development Bank (AfDB).



Source: Song, S http://manypossibilities.net/african-undersea-cables/

Map 1: Prospective African undersea cable system

3 UHURUNET is the submarine segment of the network in Eastern/Southern Africa; UMOJANET is the terrestrial component.

4 See http://www.egy.org/egyafrica.php

5 EASSy, Eastern African Submarine Cable System; KDN, Kenya Data Network; TEAMS, The East African Marine System; SEACOM, Southern and East Africa Communications.

In short, Southern Africa's current hopes of accessing and deploying the 'dazzling technologies' invigorating higher education and research in the developed world rest on the following:

- the successful completion of the various undersea cable projects;
- the deployment of NRENs in every country in the SADC region;
- active measures by universities in each country to accelerate the uptake and usage of the capacity of existing NRENs and of new NRENs in formation, in order to foster research collaboration in the SADC region;
- translation of the stated determination of political leaders to connect African education and science to the world into explicit policy to advance the formation of NRENs and their connection to a regional REN;
- the design of new regulatory frameworks in each country to provide the enabling environment for NRENs to operate effectively and at reasonable cost, while eliminating barriers to their advancement; and
- the ability of markets to take advantage of the foregoing to connect Africa to the world through the undersea cable systems.

Are these factors sufficient and appropriate to fulfil expectations of high-speed connectivity for higher education research and teaching? What challenges, obstacles and possible cross-purposes must be cleared? What opportunities, potential and conditions must be created to facilitate rapid evolution of network capacity and greater utilisation?

Enabling conditions and constraints for national research and education networks (NRENs) in Southern Africa

In Southern Africa, as elsewhere, the rise of the Internet can be largely attributed to the academic and research community. Universities introduced or pioneered access to the Internet in South Africa (UNINET made its first TCP/IP connection in 1991); in Zambia (in 1994 the University of Zambia established the country's first ISP, ZAMNET); and in Mozambique (Eduardo Mondlane University went online in 1995). The first physical multi-country academic and research network in Africa was the East and Southern Africa Network (ESANET), established in 1991 to connect universities in Uganda (Makerere University), Kenya (University of Nairobi), Zambia (University of Zambia) and Zimbabwe (University of Zimbabwe) (Twinomugisha, 2006: 6-7). The current limitations in Internet usage for educational and research purposes can be addressed through a number of measures, in particular through the introduction of dedicated national research and education networks (NRENs) and regional RENs (RRENs).

NRENs are publicly-funded, interconnecting fibre backbone networks that are designed to operate for a distinct sector, the higher education and research sector, often in the context of the development of national innovation systems. Data transfer across these electronic networks at high speeds enables knowledge sharing and online communication among research teams, and with post-graduate research students, linking academic communities irrespective of their geographic location. It is argued that NRENs play both a supporting role for research delivery by enabling data transfer and communication, and a direct facilitation role in that they enable research teams to construct virtual platforms for experimental design and research collaboration. Regional RENs are typically the work of special

agencies, such as DANTE[6], established by eleven European NRENs to design, create and operate advanced networks for research and academic collaboration across Europe. DANTE also undertakes projects to promote research networking in Europe, as well as to create Internet infrastructure in other regions of the world for the purpose of linking researchers in these countries with researchers in Europe (DANTE, no date).

Given a context of improved future global and local connectivity through a much advanced African undersea cable environment as discussed above, the evolution to 'established NRENs'[7] in Southern Africa could lead to greater research collaboration. This would compare favourably with the existing low levels of collaborative output from Southern African and African researchers (a small productive pool of researchers from Botswana, Cameroon, Kenya, Malawi, South Africa, Tanzania, Zambia and Zimbabwe). It is noted that the levels of collaboration of African scholars with researchers in regions other than the African region is significantly greater (UK, USA, Australia, Canada and Europe) (Mouton, 2007: 270-272)[8], and this research networking can also advance on the basis of the operation of a larger number of established African NRENs as well as RRENs.

The emergence of African NRENs is aimed at gaining access to high capacity bandwidth to enhance research capacity and output, but these networks have evolved under circumstances of continued dependence on satellite and dial-up connectivity (Martin, 2006b: 6-8). The objective in view by Southern African universities is for high-capacity (at least 100Gbps) backbone networks across countries and the region; open access to these networks using any available fibre; network convergence towards an African regional REN; and access to the European REN Géant as well as to other international networks (Martin, 2006a: 20; Martin 2008: 7). This strategic objective is based on the recognition that the existence of broadband infrastructure for general Internet use is not sufficient to address the particular needs of research entities and that infrastructure must be dedicated to the needs and purposes of higher education, particularly research.

An overview of the work of Ubuntunet Alliance[9] and a review of the FEAST roadmap (European Commission, 2009b) illustrates that NRENs in Southern and Eastern Africa (Democratic Republic of Congo, Kenya, Malawi, Mozambique, Rwanda, South Africa, Tanzania, Uganda and Zambia) are focused both on promoting national research missions and on formation of an African REN, while new RENs are being established in Botswana, Lesotho, Mauritius, Namibia, Swaziland and Zimbabwe. The functionalities of these NRENs are uneven and still maturing, according to Barry (2008) as presented in Map 2 below. The most advanced countries in this regard are Kenya and South Africa, with KENET (Kenya Education Network) and TENET (Tertiary Education Network) focused on ensuring the availability and affordability of high-speed networks to support using the Internet in academic teaching and research. An important function of emerging African NRENs/RRENs will be to act as bandwidth purchasing consortia (Martin, 2006a: 9; Martin, 2006b: 8-9). This purpose has been a central part of the work of TENET.

KENET (Kenya) and the new SANREN (South Africa) will extend current research networks to include research institutions, with SANREN planning to connect 50 higher education and

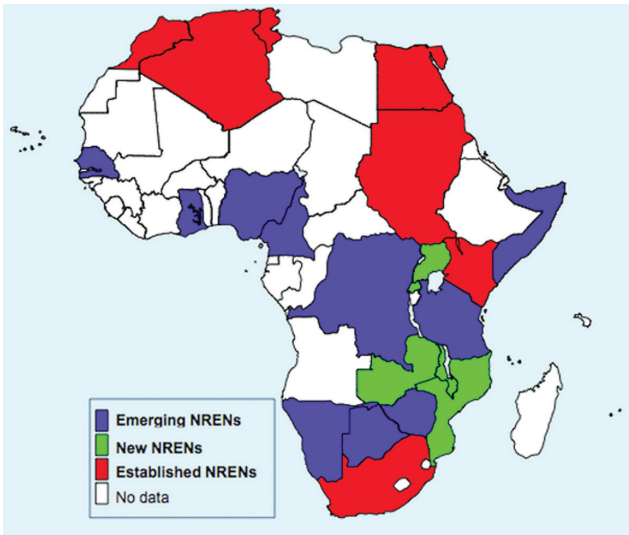
6 Delivery of Advanced Network Technology to Europe

7 Barry, B (2008) uses a typology of established, new and emerging NRENs.

8 This is a limited view of research collaboration based on publication in ISI-listed journals.

9 http://www.ubuntunet.net

research institutions to its 10Gbps network by 2010, and thus also to higher education and research institutions abroad (DST, 2009). While one of SANREN's major objectives is to position South Africa effectively for the competitive bid for the Square Kilometer Array radio-telescope project, the effective increase in research output as an outcome of the utilisation of SANREN's capacity is a thing of the future.



Source: Barry, B (2008)

Map 2: Status of NRENs on the African continent

According to Barry (2008), RENs are important for Africa because they are one of the only possible means for African scientists to connect to each other and for global research teams to move from an era of research isolation to an era of research collaboration. However, this can only occur when publicly available bandwidth becomes affordable for universities. Making broadband infrastructure and services available and affordable is the mission of the Pan-African regional REN, the UbuntuNet Alliance for Research and Education Networking (UA), formed in 2005 with the active support of Southern African and African higher education associations and of international development and donor organisations. The purpose of UbuntuNet Alliance is to support the development of NRENs in Africa and to organise and operate regional RENs for sub-Saharan Africa. These RRENs would then connect to GÉANT[10] and GÉANT2 (Europe) and other RENs worldwide, for example, Internet2 (global north) and RedCLARA (global south). In theory, these linkages should encourage sub-regional and international research collaboration, with African countries benefiting from indigenous research and knowledge production. However, infrastructure alone may not be sufficient to produce a shift towards indigenous research agendas and outputs.

In 2008, following a consultative process with stakeholders and technical specialists, the European Commission (EC) commissioned a feasibility study (FEAST) that would inform the

10 According to the project website, www.geant.net/pages/home.aspx the GÉANT RREN and the European NRENs currently connect 40 million users across 40 countries and 8 000 institutions.

measures being taken to connect African higher education and research institutions with each other and with Europe. A major objective of FEAST is to provide a roadmap to implement the EC-sponsored AfricaConnect initiative. The initiative will support the establishment of sustainable and extendable regional backbone networks dedicated to the interconnection of African NRENs to each other and to the world via the pan-European GÉANTNetwork. The EC has already successfully undertaken similar initiatives for Latin America (RedCLARA), North Africa and the eastern Mediterranean (EUMEDCONNECT2), Asia-Pacific (TEIN3) and central Asia (CAREN).

A pre-condition for a country's participation in the AfricaConnect programme is an effectively functioning NREN. The FEAST Roadmap (EC, 2009b) contains assessment criteria for this, which include adequate staffing and capacity, published acceptable use and connection policies, interconnected campus networks and identification of research projects that will utilise the RREN services. In Southern Africa, Kenya and South Africa meet the set criteria, with Mozambique and Rwanda requiring a few simple actions in order to meet the criteria for participation (DANTE, 2009: 23–24).

The FEAST study (EC, 2009a) and the associated Pehrson et al (2009) paper make the following observations with respect to the prospects for connecting African researchers to their global peers:

(a) There are mutual benefits for both the African and non-African research and academic communities in setting up relationships for future collaborations in knowledge production.
(b) There has been significant development of backbone infrastructure in the region, bringing real opportunities for the connection of African researchers to their global peers.
(c) Ten African NRENs and academic communities (less than a fifth of African countries) are at a level of readiness to connect operational terrestrial networks in the initial phase of AfricaConnect.
(d) High-bandwidth undersea cables being deployed or constructed along the east coast of Africa bring the potential of high-bandwidth/low-cost closer to the African market. Terrestrial optical back-haul infrastructure to serve land-locked countries is already being designed and commissioned.
(e) Institutional and national transitions to exploit these transformative infrastructures will require extensive cooperation between government and institutions, capacity-building for academics and technical staff, and investment in campus ICT facilities and local access networks.

The change in research output as a result of NREN operations in Southern African countries, and as a result of the operation of a regional REN for the continent, will be an important subject for future study. For now, a framework for understanding the performance of NRENs and regional RENs from the perspective of universities and the regional higher education system requires some attention. This framework can be crafted by reviewing a number of constraints to research networking.

Constraint 1 Multiple infrastructure layers for NREN effectiveness

A major constraint to be dealt with on the way to high-speed connectivity has long been evident: lack of campus-level infrastructure and facilities for bandwidth management. While attention is given to the accelerated provision of undersea cabling and national backbone fibre networks, the importance of establishing basic infrastructure inside universities cannot be forgotten, and

remains an unmet need in many institutions in the region. ICT infrastructure can be conceived as a 'layer cake' or a pyramidal set of building blocks (Adam, 2007) comprising: campus-level networks and ICT resources; the content and applications available through these resources; the way in which the campus-level infrastructure combines with national infrastructure to create an NREN; and finally, regional and global links through wider-reaching RENs. Each of these layers enables particular uses. Campus level infrastructure enables student and researcher access to electronic academic resources that can be cost-effective for resource-constrained institutions, for example, multiple-access electronic journals versus a single hard copy in the library. NRENs offer opportunities for in-country collaborative research practices and linkages to regional and international RENs.

However, at the simplest level, the challenges associated with campus-level networks in Southern African institutions include the uneven mix of technologies as a result of donations from partner institutions in developed countries; demands for continuous upgrading of systems to keep pace with technological developments and user needs; and the multiple purposes to which scarce ICT resources must be applied, including administration, teaching and learning, research, and special scientific applications. At the more complex layer of regular interactive research collaboration and knowledge exchange, the effective operation of NRENs requires all campuses in a higher education system to have well-managed fibre backbone and to achieve sufficiently fast connectivity speeds for online collaboration and data transfer. This is seldom the case, as few countries in the region have established organisations that can manage the bandwidth environment for the system as a whole.

Progressing effectively through these layers to connect researchers across Southern Africa with each other and the world is of the utmost strategic importance, as it is here that knowledge is created and assimilated, not merely accessed, creating the opportunities for customised solutions to regional developmental challenges.

Constraint 2 Vision of education and research networking

A second constraint for advanced higher education and research networking is limited vision and/or understanding within and across the various involved sectors, perhaps indicating a 'development policy divide' as much as a digital divide (Nishimoto & Lal, 2005). The paradigm shift required for envisioning Southern African universities in the digital age has to occur across a spectrum from a purely technological take on the issues to a full recognition of the developmental purposes to which the knowledge flowing across these networks can be put. Political and system-wide advocacy would need to focus on such themes as the significance of ICTs for Africa's future knowledge development in important fields such as public health, earth science and climate change, as well as for country competitiveness and broad social inclusiveness. Such a vision can bring institutions to focus on the value of NRENs and RRENs. These ideas were keenly taken up in the discussion forums and activities of the AAU and SARUA (when established in 2005), culminating in the agreement to establish the UbuntuNet Alliance, announced at WSIS 2005. But the work of building a collective vision does not end there.

The work of building or consolidating national and regional RENs involves a range of partners in distinctive roles. For example, UbuntuNet Alliance is a technical organisation focused on deploying the necessary fibre infrastructure to connect its member institutions, but currently lacks the necessary political support to negotiate the complex campus-politic and national regulatory environments in order to access existing fibre resources. SARUA,

on the other hand, is a facilitative organisation with the potential to marshal 'political' support at the institutional and regional level but that lacks the technical capacity to carry out any ICT implementation activities (Twinomugisha, 2007: 49). These complementary roles can be elucidated to forge a vision for a new era of research productivity.

Regional multi-country collaboration, for the purposes of delivering NRENs and RRENs, must be underpinned by a regional political consensus that mobilises the necessary policy, regulatory, funding, human and other resources. Researchers and academics must be engaged with the processes of NREN and RREN formation as the user community that will make these investments viable. Yet the kinds of issues needing to be broached are often complex and sensitive, involving competing regional and national goals, priorities and approaches. These will play out at levels beyond the ambit of the higher education sector. For example, differences of opinion between the Kenyan and South African governments as to whether EASSy should be controlled by the private sector or be an open access system have meant the two countries have taken separate paths in their quest to access bandwidth for broadband communications.

In circumstances such as these, the higher education voice must continue to make itself heard as a consistent advocate of broadband communications to support long-term developmental interests in (Southern) Africa rather than to meet a series of contingency needs, whether they be the SKA-bid or any other particular case. Southern African higher education must articulate a vision and plan for research collaboration and networking, at regional and international levels, that will guide its participation in the work of the Ubuntunet Alliance and in the projects such as AfricaConnect. This vision must incorporate an explicit view of the research role of higher education institutions with respect to the knowledge needs of the region, as well as with respect to knowledge that can be generated for the purposes of exchange with other regions of the world.

Constraint 3 National policy on research collaboration and networking

A third constraint on higher education's access to affordable high-speed connectivity, is a national policy environment in which ICT policy lacks a perspective on higher education networking needs and, conversely, higher education policy lacks a perspective on ICT and RENs as an important resource. Regrettably, there are all too many examples of governments in the SADC region restricting broadband access (and well-functioning telecommunications markets) through inertia, misconceived policy directions and inappropriate regulatory controls and institutional arrangements (Pehrson et al, 2008: 11). If SADC governments are to facilitate the development of successful NRENs and an RREN, then supportive and integrated policies and regulatory frameworks for education, science and technology and communications are essential. Public funds should leverage private sector funding for bringing in the new telecommunications infrastructure, whilst establishing the principles of open access to the telecoms backbone and undersea cable for NRENs and RRENs.

Governments in the region need to adopt policies that encourage competition in telecommunications markets, while creating the policy foundation for the operation and funding of NRENs. Furthermore, regulatory frameworks must enable accessibility, affordability and availability of the requisite ICT resources through setting the rules of the game for competition, through promoting technological convergence (ibid), and through considering measures such as cost-based pricing and low cross-border interconnection rates. Such national reform and regional harmonisation efforts will require governments to

create, fund and strengthen independent regulators in the broad communications sector (Martin, 2006b; SARUA, 2006; World Bank, 2005). These measures are necessary both to ensure the effective functioning of NRENs and of the broader telecoms landscape within which they function.

Most importantly, the purposes to which national and regional RENs will be put, in support of research collaboration and higher learning, need to be adumbrated and supported with effective public financing of higher education research agendas and evolution of public-private-development sector research activities.

Constraint 4 Cost of NREN connectivity

The fourth, ever-present constraint upon the expansion of RENs in Southern Africa (and ICTs generally) is cost: bandwidth remains expensive across the SADC region, even though costs have come down. In the past, the financing of submarine cables has tended to occur in a closed 'shareholders' club' model (Pehrson et al, 2008: 6) and this business model may continue with the introduction of new cable systems. Continued high costs support the motivation for open access models for securing broadband connectivity. However, the workability and eventual success of this approach is untested and will hold many lessons for a developing country perspective on NREN connectivity.

This debate regarding closed club versus open-access models raises two important points for universities and policy-makers: (a) It underscores the high importance of NRENs in Southern Africa serving as bandwidth consortia, thus creating economies of scale, negotiating affordable Internet access and the terms of access for member institutions, and sharing the costs of connection to international RENs; and (b) it raises the issues of effective policy and regulation as a means of obtaining affordable broadband connectivity – and of reducing the negative effects of closed models of provision.

Key performance indicator framework for Southern African NRENs and RREN – a universities' perspective

Southern African scholarly research and communication stand at the cusp of change. One of the resources required to tip research collaboration into an era of greater productivity is access to high-speed, low cost bandwidth through dedicated networks.

The importance of cooperation and collaboration within the SADC region in the interests of securing bandwidth to establish NRENs and a RREN is fully acknowledged in principle by the Southern African higher education sector and governments. However, the practice of regional co-operation and collaboration requires strengthening.

For this reason, SARUA needs to assume a set of facilitative roles and interfaces (similar roles can be extrapolated in the case of other regional and continental associations), to ensure the advocacy of RENs to all role-players within and outside the sector, and to promote the participation of member institutions in research networking and REN-related initiatives. It needs to develop a set of strategies to ensure that Research and Education Network issues remain on the agenda of regional political bodies, as well as those of national Ministries and government departments. The development of constructive relationships and alliances with governments, regulators, private sector partners and donor agencies, as well as with the governance, management, technical and operating structures of initiatives for broadband access and scientific networking, remain essential points of interaction.

Furthermore a 'watching brief' on the evolving goals, strategic objectives, funding, operational plans and functioning of NRENs and the RREN needs to be maintained, to ensure that these are clearly derived, articulated, developed and tracked.

A four-tier model for crossing the digital divide in African higher education and research is emerging, constituted as a layered design of campus level infrastructure, national RENs, regional RENs and linkages to RRENs in various parts of the globe. Key performance indicators for the evolution of this model, derived from the discussion above, would include those listed in the following matrix. This presents a view for higher education management, including academics in charge of research, teaching and libraries, to work towards and evaluate on an annual basis.

Matrix 1: KPI framework for analysing the success of RENs

Layer	KPI
	Annual reports on quantitative measures and qualitative reviews
Campus-level focus	Agenda/index of research projects utilising NREN services
	Access to bandwidth and support services through membership of a bandwidth purchasing and management consortium
	Capacity for deployment and maintenance of new ICTs and advanced teaching and research applications
	Assessment of the cost of connectivity for current and future years
NRENs	Affordable, dedicated high speed connectivity for researchers, academics and students offering fast download and upload speeds and research platform capability
	Active levels of research networking and increased participation of African scientists in regional and global knowledge production
	Emergence of strongly indigenous research agendas and outputs in tropical medicine, earth science and other research fields of local and global importance
	Success in competitive bids for globally-relevant research (for example, SKA or climate change)
	Capacity of the academic and research population to maximise the use of advanced networks for research collaboration
	Cost and sustainability of NREN operations
RRENs	Success in acting as bandwidth purchasing consortia to achieve affordable prices
	Cross-border connectivity to enable research collaboration across African countries
	Success in competitive bids for globally-relevant research by regional research teams
	Cost and sustainability of RREN operations
Linkages to other RRENs	Levels of participation in research collaborations and access to knowledge on a global scale
	Cost and sustainability of international linkages

This matrix can be expanded according to the specific needs of particular universities or higher education sectors.

Conclusion

With an estimated 262 million people living in the SADC region (AfDB, 2009: 30–31), Southern African higher education must increase its formative and transformative capabilities in its three main focus areas – teaching and learning, research and scholarship, and societal engagement. This it must do in order to foster future generations that will contribute to the construction of a 21st century economy, through fostering economic development and through creating new knowledge.

The digital divide experienced by Southern African universities is a challenge that needs to be addressed if we are to compete in the global knowledge economy. There is a shift in political will in Africa towards addressing this divide, including commitment from institutions such as the AAU and SARUA. Significant private sector initiatives have begun to provide much-needed

broadband infrastructure and capacity to the region. International donors, the European Community in particular, aim to support the continental development of regional RENS. There are, however, constraints that remain to be overcome.

The higher education sector seeks to overcome the relative isolation of African scientists and researchers, and to enable them to deploy knowledge for regional/continental development and integration. In Southern African higher education today, the focus is on leapfrogging from (still inadequate) basic ICT infrastructure to those emerging networks that provide dedicated high-speed connectivity and services to users in higher education and research institutions internationally. While universities and research institutions pioneered the use of the Internet, they now strive to overcome the relative isolation that African scientists and researchers are experiencing. Educationists, university leaders and policy-makers must adopt a frame of reference and key performance indicators for African research networking and infrastructure that will support these goals. A formative framework is presented in Matrix 1 above.

The collaborative efforts of Southern African institutions, higher education sectors and governments, along with organisations such as SARUA, Ubuntunet Alliance and DANTE, need to ensure that the digital divide is narrowed and the isolation of Southern African Universities ends. ❑

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