Useful Flexibilities for African Regional Research and Education Networks

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Abstract

The UbuntuNet Alliance is conceived of as an association of NRENs in a given region. The hierarchy Institutions → NRENs → Regional RENs characterises what may be called "the standard REN model". Regional RENs provide transit to their member NRENs and interconnect with each other over interregional distances. The standard REN model expects no more of any Regional REN.

The standard REN model evolved principally in Europe. In the writer's view, the circumstances of African countries are too widely disparate for continued as-is adoption of the standard REN model. Greater flexibility is needed to allow UbuntuNet and other Regional RENs of Africa to serve universities that can be reached but are not yet served by an operational NREN.

For example, some countries simply have too few universities to sustain the overhead costs or engender the significant buying power of an NREN. To overcome this, Regional RENs could offer a "catch-all" REN service to individual institutions that are not served by a recognised NREN.

Some African countries are too large, too diverse culturally and/or too patchy in their infrastructural development to enable the ready establishment of a single NREN. Instead, collaborative REN organisations could be established at the sub-national level, and Regional RENs should accept such "District RENs" as legitimate customers.

A Regional REN could also act as a proxy NREN in a country in which the universities use commercial ISPs but no organised NREN has emerged, and so facilitate the founding of a real NREN.

Keywords

Research and Education Networking; UbuntuNet; Connecting Universities; Africa; NREN

The standard REN model

NRENs

The NREN (National Research and Education Network) of a country is conceived of as a non-commercial organisation that provides a variety of Internet-related services to the education and research institutions of the country.

NRENs may differ from each other in major ways such as the scope of their services, the eligibility criteria for participation and their governance and funding models. However all NRENs have in common their nation-wide scope, their non-commercial business model, and their obligation to ensure the direct connection of the institutions that they serve to the worldwide research and education network.

John Dyer's well-known article [Dyer, J. (2009)] sets out the case for countries to establish and sustain NRENs, while the article [Khunga, B. & Kunda, D. (2015)] draws useful lessons from the successful establishment of ZAMREN, the Zambian NREN.

Regional RENs

In a similar but simpler way Regional RENs such as ASREN, GÉANT, RedCLARA, UbuntuNet and WACREN are conceived of as associations of the NRENs of countries that fall within a specified regional cluster of countries. Regional RENs provide transit services to their member NRENs and they interconnect over interregional distances with each other. Each country has its NREN, or is establishing one, and a Regional REN's only downstream networks are those of its connected member NRENs.

This is reflected in the simple mission statement of the UbuntuNet Alliance, which reads as follows: *To secure affordable high speed international connectivity and efficient ICT access and usage for African NRENs.* (See http://www.ubuntunet.net/vision_mission)

The cluster of countries served by a Regional REN often has a political identity. For example, Géant serves the NRENs of Europe, and enjoys sustained support from the European Commission. By contrast, UbuntuNet's Region[1], which is referred to as "Eastern and Southern Africa", does not coincide with SADC or EAC or with any other established political grouping of countries.

REN versus commodity networks

NRENs and Regional RENs have in common their adherence to open interconnection policies, their mutual recognition of each other's bona fides as RENs, and the concomitant recognition of each other's ASNs as REN ASNs. The REN community refers to non-REN networks as "commodity networks".

This distinction should not be seen as separating the good guys from the bad guys! Universities and research institutions need and use access to commodity networks just as much as – some would say more than – they need access to other RENs. For example, many online scholarly journals are hosted on commodity networks. Google search requests go to a commodity network. Important mirror sites such as SourceForge are on commodity networks as are important open source repositories such as GitHub.

However, the distinction is vital for describing current interconnections practice – i.e. what RENs must do, may do, and may not do, by way of interconnecting with other networks.

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[1] The DRC, South Sudan and The Sudan, viewed together, form a great swathe that runs for some 4,000 kilometres from the Congo River's mouth on the Atlantic seaboard, north-east to the Red Sea, and so bifurcates the African continent. The UbuntuNet Region comprises these three countries and all those to the south of this bifurcating swathe, together with the island countries in the western reaches of the Indian Ocean. There are twenty-six countries in the UbuntuNet Region, of which five are island countries off the east coast of the continent. Réunion is not included as it is a French territory.

First, all RENs must provide "REN transit" to their downstream customer networks. This means that they provide IP interconnectivity with other research and education institutions, NRENs and Regional RENs *worldwide*. Some NRENs, especially in the more highly-developed regions of the World, provide only such a REN transit service.

Second, RENs may provide a commodity transit service to their downstream REN customer networks. This is currently the case for all African RENs, and for the obvious reason that it eliminates the need for the downstream customer networks to carry the costs of separate infrastructures to carry their REN traffic and commodity traffic. In Europe, GÉANT offers a commodity transit service, but imposes an upper limit on the proportion of commodity traffic. Some European NRENs use it. Many European universities procure a commodity Internet service from commercial ISPs and take only the REN transit service from their NREN.

Third, no REN may carry traffic that is neither sourced from nor destined for a REN.

RENs implement such rules through judicious control of their BGP route announcements to commodity networks.

The purpose of these rules is to keep the capacity of REN backbones and REN interconnections available for traffic flows between RENs. A former CEO of Internet2 once said in answer to a would-be detractor: *Yes! You're right! Internet2 is indeed almost empty! That's how it should be – waiting for the next transfer of a massive dataset!*

The Standard REN Model

The hierarchy: Institutions → NRENs → Regional RENs, in which NRENs and Regional RENs fulfil the distinct roles described above, characterises what may be called *"the Standard REN model"*. Of course, it is no more than a business model. It is nowhere enforced by law or authority, but is widely reflected in service agreements between Regional RENs and their member NRENs, and between NRENs and their member Institutions.

There are several well-known instances of deviations from the standard model, especially as regards the exploits of NRENs. For example, in Europe, there are instances of pairs of NRENs establishing a direct, high-speed interconnection between themselves, notwithstanding their mutual interconnection via GÉANT.

Both China and Egypt have two NRENs - one for universities and one for research institutions, possibly because universities and research organisations fall under different government ministries.

In the 1990s and early 2000s the National University of Lesotho and the University of Swaziland were both connected to and served by the South African NREN, UNINET, and its successor, TENET. This deviation from the Standard REN Model started in the days before incumbent telcos had noticed the Internet, and ended when the local incumbents, first in Swaziland and subsequently in Lesotho, took over the provision of Internet services to their national universities.

An interesting deviation concerns NorduNet, the Regional REN that serves the NRENs of the five Nordic countries, which was founded some 15 years before the EC's Géant Project started off. NorduNet did not become subsumed as part of Géant, and it continues to this day independent of, but collaborating with Géant. Its network has PoPs in each of the Nordic countries, and also in Amsterdam, Frankfurt, London, New York, Miami and San Francisco.

As mentioned above, the UbuntuNet Alliance was conceived as a regional REN according to the Standard REN Model, and so far neither it nor its connected NRENs have deviated from the Standard REN Model.

Quantifying the reach of the NRENs of the UbuntuNet Region

Of the 26 countries in the UbuntuNet Region, 15 have NRENs that are members of the Alliance, and of these, ten are operational and providing services to one or more universities and research institutions. They are: BERNET (Burundi), EthERNet (Ethiopia), iRENALA (Madagascar), KENET (Kenya), MoRENet (Mozambique), RENU (Uganda), SudREN (Sudan), TENET (South Africa), TERNET (Tanzania) and ZAMREN (Zambia).

Saying that 10 out of 26 countries (i.e. 38%) have operational NRENs is a pretty crude way of quantifying the reach of research and education networking in the Region. A better way is to *count universities* – i.e to express the number of universities in the 10 countries with operational NRENs as a proportion of the total number of universities in the 26 countries of the Region. The web site of the Association of Africa Universities (AAU) lists the universities in each African country that are members of the AAU. There are some 140 member universities of the AAU in the UbuntuNet Region, and it turns out that almost 100 – i.e. some 70% – of them are located in the 10 countries with operational NRENs.

An obvious improvement to this method, but one that would require data collection from the NRENs, would be to count universities that are actually served by the NRENs.

Why are there not more operational NRENs?

The central role of the NREN

The Standard REN Model is centred on the NREN as the vehicle for the collaborative provision of research and education networking services within nation states. This undoubtedly reflects the environment in Europe where countries have sufficiently many universities and research institutions to justify and sustain NRENs and also have sufficiently de-regulated communications sectors to permit NRENs to form and function effectively.

Notwithstanding the successful operation of UbuntuNet itself and of several NRENs in the Region, it is the writer's view that the circumstances of African countries are too widely disparate for continued as-is adoption of the Standard REN model. Critical national factors include the number of universities, the extent to which the market power of the incumbent monopoly has been tempered, the lack of funds to seed and evolve an NREN to self-sufficiency, and the willingness of government to devolve control of the NREN to the institutions. These factors, which are denying many African universities worldwide REN connectivity, are discussed in the following sections.

Factors that inhibit the formation of NRENs

Too few universities: Some countries in the Region have only one or perhaps two multi-faculty universities. Examples are Botswana, Lesotho, Malawi, Namibia and Swaziland.

In economic terms an NREN justifies itself, especially in its early years, through aggregating the bandwidth demand of its member institutions and so securing volume discounts that cover

the NREN's overhead costs and benefit all members. These economics fail when there are too few universities.

Overly powerful incumbents: Some countries have regulatory regimes that allow incumbent telcos to continue to dominate the national market, especially as regards transmission capacity and especially as regards governmental and parastatal customers. Incumbents fear the consequences of treating NRENs as special cases that cannot be expected to pay the going rates, and also dislike the desire of NRENs to have their own ASNs and to do their own routing. NREN formation in many countries of the Region was or is being hampered in this way. In particular, this factor is at play in the failure of initiatives over a number of years to establish operational NRENs in Botswana and Namibia.

Lack of seeding resources: An NREN is not just a club. It is an operating business (albeit a non-profit one) with, inter alia: bank accounts, customers, suppliers, services, service contracts, creditors, debtors, prices to be set, auditors, taxes to be paid, a Board of Directors, a constitution, governance processes, communications licenses, policies, employees, a CEO, routers, servers, rented network capacities, etc. Conceiving and launching a new NREN is a significant project that requires significant seeding resources: (a) a project team that brings together contacts in the universities, good understanding of what has to be done, and business experience; (b) a respected retired Vice-Chancellor or other senior university personage to act as the public face of the project (Project Sponsor); (c) an identified person who is going to become the first CEO and is available full-time; and (d) working capital from which to bear the travel, workshop, secondment, salary, accommodation, legal and other expenses of the project until such time as the NREN is operational and generating sufficient revenues.

In the writer's view it is primarily the lack of seeding resources that has denied Zimbabwe an NREN. Zimbabwe has many universities, a well-developed telecommunications infrastructure and a de-regulated telecommunications regime with at least three competing operators each of which serves a number of universities. Prices are quite low, which weakens the viability of a start-up NREN and makes seed funding essential. Notwithstanding several meetings of Vice-Chancellors and representation at several UbuntuNet meetings, an adequately conceived NREN has not materialised.

Failure to evolve from project to sustainable NREN: In many countries the establishment of an NREN was (or may be) first started by a government department or parastatal authority. Start-up funding by the World Bank or international donors is often available to such public initiatives. Examples include:

- South Africa (UNINET Project of the Foundation for Research Development, a parastatal institution, 1987)

- Kenya (Department of Education, funding from the USAID Leland Initiative, 1999)

- Mozambique (Department of Science and Technology, World Bank funding, 2006)

- Rwanda (Department of Education, 2006)

- Burundi (Executive Secretariat for Technology, Information and Communications, World Bank funding, 2013).

The provision of Internet access to the universities was the primary objective of such projects and their funders. This was well understood, and governments can readily call upon the services of incumbent operators to provide such services.

What is not always understood is the importance of establishing a *membership-based* NREN as the vehicle that will sustain and develop such Internet service provision into the future.

The role of the initiating department or authority is not just to initiate research and education networking in the country, but also to ensure the establishment of an organisation that has the support of the universities and research institutions and that can assume responsibility for sustaining and developing research and education networking across the country and into the future.

Membership-based NRENs were established in Kenya, South Africa, Sudan and Tanzania; and is this now happening in Burundi, and Mozambique.

A more flexible De-Facto Model for Regional RENs

This paper advocates that the UbuntuNet Alliance should be willing to deliberately deviate from the Standard REN Model in certain specific ways to ameliorate the hindrances to NREN-formation described above, and indeed, where applicable, to overcome the absence of an NREN. A more flexible de-facto REN model is needed that allows UbuntuNet and perhaps also other Regional RENs of Africa to serve universities that can be reached but are not yet served by an operational NREN. Some ideas in this regards are presented below.

What about a "catch-all" service?

As mentioned above, there are still many countries in the UbuntuNet Region in which there is little prospect of an NREN being established in the foreseeable future. In total there are some 40 universities in the Region that are members of the Association of African Universities but have little prospect of being served any time soon by an operational NREN.

However, for such universities, there could be a simple win-win outcome, with no injured parties, if the Alliance were to offer "catch-all" membership and REN services to them. Such institutions would become members of the Alliance, perhaps in a special "catch-all" category, and would connect to UbuntuNet and use UbuntuNet's services. Sensible modifications to UbuntuNet's policies would be needed to ensure that the eventual establishment of new NRENs would not be prejudiced.

Where a country has one dominant "national" university and a number of smaller higher education and/or research institutions, the Alliance could accept the dominant institution as a catch-all member provided that the smaller institutions are permitted to share the same connection to the UbuntuNet network. Such an arrangement would stimulate the formulation of a business framework for collaborative networking that could evolve into an NREN.

Interestingly, such a "catch-all" REN service would be akin to the catch-all sign-on services offered to individual scientists by some identity federations. It would constitute quite a significant elaboration of the Alliance's role and would need to be guided by well-informed policies and case-by-case investigations and preparations. In any country the Alliance should always, as a first priority and option, seek to support the emergence of an NREN. It should only offer services itself to the institutions of a country only with the support of the institutional leaders concerned, and preferably concurrently with renewed efforts to establish an NREN.

What about District RENs?

Some African countries are too large, too diverse as regards language and culture and/or too patchy in their infrastructural development to enable the ready establishment of a single NREN. In such circumstances, NREN-like organisations could be established at the sub-national level, and Regional RENs could accept such "District RENs" as legitimate customers.

Such an approach could possibly speed up the process of reaching the many universities in the DRC, where the current efforts to establish Eb@le, in both organisational and networking terms, are concentrated in and around Kinshasa.

Again, sensible modifications and additions to policies would be needed; for example, to facilitate the merger of such District RENs into a single NREN once circumstances so permitted.

What about the Regional REN as a proxy NREN?

The Alliance is in a position to establish REN connectivity in countries such as Zimbabwe that have relatively well-developed infrastructure and in which the universities use the services of commercial ISPs, but in which no organised NREN has emerged.

Working closely with some path-finder universities, the Alliance could secure an allocation of IP addresses from AfriNIC, with which the universities would renumber the external interfaces on their networks. The Alliance would also secure an ASN from AfriNIC, and acquire a BGP-capable router – the proxy-NREN router – to deploy at a suitable Internet Exchange. Finally the Alliance would connect this router to the UbuntuNet regional network. The universities would instruct their ISPs to provide Layer2 connections to the proxy-NREN router.

In this way a network could be established that operates like an NREN. It could be managed and operated by a local team directed (initially) by the Alliance. This proxy-NREN network, as an operational reality, would be the kernel around which the universities would come together, with facilitative assistance from the Alliance, to establish a new, membership-based NREN organisation. In due course the new NREN would take over responsibility for the network.

How can an unreached NREN or institution connect to UbuntuNet?

There are three ways in which a BGP interconnection between an unreached NREN or catch-all institution and UbuntuNet could be set up, and so enable the NREN or institution to use some or all of UbuntuNet's Internet services.

Self-provided transmission circuit to an UbuntuNet PoP

An unreached NREN or catch-all member institution could, at its own expense, rent or secure the use of a dedicated L2 cross-border circuit from its own border router to an interface on any convenient UbuntuNet device in some reached country. UbuntuNet could supply onward transmission capacity from such a device to one of UbuntuNet's border routers, and a BGP interconnection between the NREN and UbuntuNet could be set up.

An NREN is unlikely to incur the cost of such a dedicated cross-border L2 circuit in addition to incurring the charges from a local commercial provider of IP transit services. Consequently the NREN's purpose in procuring the use of such a dedicated border-crossing L2 circuit would almost certainly be to use UbuntuNet as the NREN's sole provider of commodity connectivity in addition to REN connectivity[2].

GRE tunnel to an UbuntuNet transit node

GRE tunnelling is a way of setting up a direct BGP relationship between two ASNs for which there is no transmission circuit that directly links their respective border routers. Consequently all traffic between the two networks must traverse other ASNs. The BGP packets are encapsulated so that the intervening border routers make no route announcements but merely route the packets.

An unreached NREN whose network receives a global IP transit service from a commodity ISP but is configured as a distinct ASN could interconnect with the UbuntuNet network via a GRE tunnel. Note that the NREN's network may be configured entirely within the network of a local operator and be operated by that operator. The requirement is that at Layer 3 – i.e. as an internetwork – the NREN's network is set up as a distinct network with its own ASN[3].

Note that if an NREN were to use a border-crossing GRE tunnel to interconnect with UbuntuNet, then all traffic flowing into or out of the NREN from or to UbuntuNet would be part of the NREN's international IP transit traffic. Consequently the NREN would be paying its IP transit provider (ISP) for such international traffic in addition to paying the applicable UbuntuNet charges. For this reason the Alliance should not expect such an NREN to purchase commodity IP transit from the Alliance. The NREN's purpose in connecting via the GRE tunnel would probably be limited to secure what no commodity provider can provide - access to the REN network regionally and globally.

For two ASNs to set up a GRE tunnel between them both must have upstream transit providers so that there are some IP routes between them via intervening networks. At the present time UbuntuNet purchases IP transit only in Amsterdam and London, and consequently could not terminate a GRE tunnel from any NREN on the Regional REN Backbone.

Of course at UbuntuNet's end of any such interconnection, the GRE tunnel is necessarily configured within the network of a commodity ISP *from which UbuntuNet buys IP transit services*. For such a termination to be available, UbuntuNet must buy commodity IP transit from suitable commodity operators at suitable locations in the Region.

The Alliance could provide an L2 connection

The Alliance could, in principle, procure a cross-border link between its nearest node and a suitable node in the unreached country concerned, and could treat the costs thereof as part of

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[2] ZAMREN connected to UbuntuNet in this way for many months. ZAMREN rented an L2 circuit from Liquid Telecom between Lusaka and a TENET switch in Johannesburg, and TENET provided transmission capacity to extend the L2 circuit from the Johannesburg switch to the UbuntuNet border router in Mtunzini.

[3] For many years, during the pre-UbuntuNet era, TENET interconnected with both Géant and Internet2 via GRE tunnels. Telkom SA operated the entire TENET network, including the routers, but the network was configured as a distinct autonomous system with its own ASN (AS 2018). Both GRE tunnels had a TENET border router in Cape Town at their southern ends, while at the northern ends one terminated on a Géant router in London and the other on an Internet2 router in New York City. Both tunnelled through the networks of Telkom SA and its Tier1 transit providers.

its overall cost structure. A pre-requisite for such a step could be the connecting institution's committing to an enduring minimum bandwidth order.

This suggestion entails an enlargement of the Alliance's approach to reaching countries, in which the primary determinant is that an NREN or university is willing to commit to an enduring order quantity, rather than an approach that is primarily driven through AfricaConnect's planning processes. It is worth noting that the latter approach lacks any requirement for commitments to minimum bandwidths order, as the prolonged failure of RwEdNet to connect to the UbuntuNet router in Kigali demonstrates.

In the writer's opinion, the Alliance should not be intimidated into inaction by assertions that today's traffic volumes to and from a particular institution or country are too meagre to justify a REN connection. UA's role as a stimulator and enabler is very important, and decisions to establish links should be based upon assessments of the potential for meaningful traffic volumes to develop.

Fair pricing

The Alliance's present services and prices do not differentiate between service handoff to an NREN at a node within the NREN's country ("reached countries") and service handoff at a node that is one or more border-crossings removed from the NREN's country ("unreached countries"). For an individual university in an unreached country to use UbuntuNet services, it would have to bear the cost of a cross-border link to an UbuntuNet node, in addition to which it would be charged at the same service prices as are charged to NRENs in reached countries.

In so far as the EC's major contributions to the AfricaConnect developments have benefitted some countries and not others, in the post-AfricaConnect era the Alliance would be justified in devising price schemes that made UbuntuNet connections more affordable for institutions and emergent NRENs in as-yet unreached countries.

Conclusion

For some time the writer has believed that the Alliance should be willing and able to push the boundaries of the standard regional REN model by providing services directly to universities in countries where, for whatever reason, there is no effective service-providing NREN and little prospect of one emerging. This paper advocates that the UbuntuNet Alliance should deliberately deviate from the Standard REN Model in certain specific ways when and where the connectivity and service needs of more education and research institutions of the Region would be better served by so doing.

This would constitute quite a significant elaboration of the Alliance's role and would need to be guided by a well-informed policies and case-by-case investigations and preparations. For any country of the Region, the Alliance should always, as a first priority and option, seek to support the emergence of an NREN. It should offer services itself to the institutions of a country only with the support of the institutional leaders concerned, and preferably concurrently with renewed efforts to establish an NREN.

A first step would be to determine and understand what regulatory, networking and business issues would have be addressed for universities in selected countries to be able to connect their networks to UbuntuNet and receive the Alliance's REN transit services. Strategies for and policies governing direct service provision would also need to be formulated.

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Biography

Duncan Martin was an applied mathematics lecturer and researcher and, from his mid-forties, a general manager of research and ICT services. In 2001 he was appointed as the first CEO of the South African NREN, TENET, of which he was a founding director. Together with colleagues from Kenya, Malawi, Mozambique and Rwanda, he co-founded the UbuntuNet Alliance in 2006, and served on its Board until his retirement from TENET in January 2013. He now consults to the Alliance and NRENs, and is a non-executive director of local companies including E-Schools Network, Internet Service Providers' Association and ZA Central Registry.