Research and education networking in Africa

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Abstract

Over the past seven or so years, the Internet access requirements of universities and research institutions have grown enormously. The phenomenal evolution of the web has turned computer and Internet literacy into essential life skills. The demand for general Internet access dominates institutional IT budgets. Access circuits are clogged for 18 hours or more per day.

The losers are those who started the Internet in the first place - researchers who need to exchange data files and collaborate remotely with each other. What is more, modern science has built all manner of experimental instruments that happily generate terrabytes of data per day. Thus the need of researchers for bandwidth to move huge data sets has also grown enormously.

In many parts of the World, universities have ameliorated this problem by collaborating at national and regional levels to create a family of inter-connected networks that are dedicated to carrying traffic that has originated at such an institutions and/or is destined to such an institution. Other traffic is referred to as "commodity traffic".

They are called Research and Education Networks, or RENs. Many RENs have a national scope, and are referred to as National Research and education networks, or NRENs.

There are some 35 NRENs in Europe, including, for example, JANET, SURFNet in The Netherlands, NorduNet in Scandinavia, and GARR in Italy. Other examples are AARNET in Australia, KENET in Kenya, CERNET in China, SINET in Japan, Abilene, ESNet and National LambdaRail in the USA, CANARIE in Canada and RedClara in South America.

The European Commission's famous Géant network is the World's most extensive regional REN. It interconnects the NRENs in Europe at very high speeds and provides high-speed connections to national and regional RENs elsewhere in the World. The European Commission's initiative and leadership in building Géant and in promoting and supporting Géant's connectivity to other RENs is of enormous importance and benefit to research and education world-wide.

Research and education networking in Africa received enormous publicity and attention during 2005, engendered largely through activities aimed at the World Summit on the Information Society, which was held in Tunis in November 2005. Preparatory workshops and conferences were held in Johannesburg under the auspices of the Southern African Regional Vice-Chancellors Association (SARUA), and by major US donor foundations as adjuncts to Internet2 Member Meetings. A major Conference on Research and Education Networking in Africa was held in Tunis under the auspices of the Association of African Universities (AAU) and the IDRC as an adjunct to WSIS itself.

The major development that has crystallised from these activities is the formation of the UbuntuNet Alliance for Research and Education Networking. The Alliance is a non-profit, non-governmental association of African NRENs that intends to evolve as a regional REN that will interconnect its member NRENs and provide them with inter-continental connectivity, in much the same way that Géant serves the NRENs of Europe. Membership is open to all bona fide NRENs in the target region.

The paper closes with a brief update on TENET's activities.

1. Background on research and education networks

1.1. Explosive growth, commercialisation and popularisation of the Internet

Over the past seven years, following the invention of the World Wide Web, commercial interests have dominated the growth and use of the Internet. On university campuses all over the world, the Internet ceased being a tool known only to the cognoscenti, and became an important resource that had to be made available to all staff and students. The provision of staff and students' email and access to the Web has come to dominate institutional IT budgets and the associated traffic clogs the institutions' Internet connections.

1.2. Research and Education Networks

At the same time, the ever-growing use of digital data sources, ranging from remote sensing satellites and supercomputer simulations to electronic, online learning materials and scholarly journals, has dramatically increased the need of lecturers and researchers for access to high bandwidths connectivity to other universities and research centres. Faced with the congested state of their institutions' general Internet access connections, universities in many countries established separate "private" networks that carry only traffic that is passing between member institutions, and do not provide connectivity to the Internet at large. These networks have come to be called "RENs" for "Research and Education Networks". Many RENs are created with a national scope, in that their member institutions are all the universities and research institutions within a given country. Such RENs are referred to widely as "National Research and Education Networks", or **NRENs**. There are 35 NRENs in Europe alone. Examples of NRENs are the Joint Academic Network (JANET) in the UK, SurfNET in The Netherlands, the Australian Academic Network (AARNET) in Australia, the Kenya Education Network (KENET) in Kenya, the China Education and research network (CERNET) in China, SINET in Japan, and, of course, TENET in South Africa.

In the USA there are several NRENs with a coast-to-coast, country-wide scope, including Abilene (operated by Internet2, a consortium of universities), the Energy Sciences network ESNet, and National LambdaRail (also an association of universities). There are also many RENs in the USA with statewide scope, such as the Corporation for Educational Network Initiatives in California (CENIC) and the New York State Education and Research Network (NYSERNet).

In some countries the NREN also provides access to the Internet generally as a service to member-institutions. Examples ate JANET (mentioned above) and TENET. In other countries, the NREN, like Géant itself, does not provide connectivity to the general Internet, and connecting institutions must also connect to a local Internet service provider for this purpose.

1.3. Géant, regional RENs and the Global REN

The European Commission's famous Géant network is the World's most extensive regional REN. It interconnects the 35 NRENs in Europe at very high speeds and provides high-speed connections to national and regional RENs elsewhere in the World. This includes connections to:

- Abilene, ESNet and others in the USA
- CA*Net4 in Canada
- CLARA, a regional network that inter-connects the NRENs of all countries in Latin America
- the Greek NREN GRNet and various other NRENs in Eastern Europe

- the EUMEDCONNECT network which connects the NRENs of Algeria, Morocco, Tunisia, Egypt, Lebanon, Israel and the Palestinian Authority eNorth Africa and Mediterranean countries, and to
- the TEIN2 network in the Far East, which interconnects the Chinese, Japanese, Hong Kong and Malaysian NRENs, and finally
- the TENET network in South Africa, this being the only connection to a sub-Saharan African NREN.

Géant is funded partly by the European Commission and partly through connection fees paid by the European NRENs. It is deployed and operated under contract to the EC by the non-profit company DANTE plc, which is based in Cambridge, UK.

The European Commission is playing a remarkable role in promoting European researchers' connectivity with research and education networks across the World. In particular, three of the connections mentioned above, viz those to Latin America, the Far East and North African/Mediterranean region, were conceived as projects by the EC and are still largely funded by the EC.

2. Why have NRENs evolved in so many countries?

Why did many countries create NRENs, and why did the EC create Géant, when research and education institutions could already communicate with each globally other via the Internet?

2.1. The growth of the commodity Internet

When the Internet first emerged it was a network that inter-connected computers at various universities and research establishments in the USA. From the mid-1990s, however, graphical user interfaces and the World Wide Web stimulated the rapid popularisation and commercialisation of the Internet.

The popularisation and commoditisation of the Internet have dramatically changed the face of research and education networking. The demand for email and general browsing facilities by large numbers of staff and students diverts networking resources and congests expensive Internet connections, leaving little capacity to meet the special needs of researchers for large data transfers and other high-performance network applications including participation in research video-conferences via the Internet.

The domination of research needs by general Internet access demands is especially severe where Internet access is comparatively expensive, as it is throughout Africa. Of course, many university students first encounter the Internet on campus networks, and, in learning to understand and use the Internet they gain vital life-skills. However, even in the best-connected South African universities, day after day the highly predictable aggregate demand for email and general web browsing by large numbers of staff and students threatens to swamp the capacity of the Internet access circuits and forces the use of traffic-shapers and other bandwidth management techniques that, in one way or another, ration the available bandwidth.

2.2. Primary versus secondary research

In parallel with this, information technology has impacted the methods and tools of research quite radically. In many areas, including particle physics, remote sensing of earth resources, oceanography, optical astronomy and radio astronomy, expensive measuring instruments routinely gather massive amounts of digital data, within which scientific illumination hopefully awaits the analyst. This has led to an important dichotomy between "primary" and "secondary" research. In primary research, well-funded teams build great instruments, perform experiments and capture oceans of data. Secondary research is the extraction of

patterns, insights, lessons, conjectures and other intellectual harvests from the data ocean. The researcher can do this anywhere, provided that he or she has adequate access to the data ocean and to adequate computing resources.

2.3. Grid computing

Grid computing is the ultimate evolutionary target of distributed computing, in which the speed with which data flows between computers on the network compares with the bus speeds of the individual computers themselves. Géant supports many grid projects. Development and use of grid services is a major driver of Australia's Grangenet (Grid and Next Generation Network, http://www.grangenet.net) that has points of presence in Brisbane, Canberra, Melbourne and Sydney.

2.4. And so….

Taken together, the three factors discussed above mean that general Internet services, while providing email and browsing services to campus communities generally, do not meet the needs of educators and researchers for very high bandwidths between collaborating sites and for access to networks that support leading edge protocols and applications. The response in many countries has been to create an NREN to cater to the connectivity requirements of research and education organisations.

In the research and education networking community, Internet traffic that flows between campus networks that are connected directly to NRENs is called "*research traffic*". Traffic for which either the source or the destination is not connected to an NREN is called "*commodity traffic*". Note that the distinction has nothing whatsoever to do with the content or payload of the traffic. *The primary business of RENs throughout the World is to provide high bandwidth, low latency routes for research traffic.*

3. Some notable REN activities

3.1. Pioneering hybrid architectures

The Canadian NREN organization CANARIE has been experimenting with switched light path and user-controlled light path (UCLPs) technologies for some years. As the names suggest, these technologies represent a reversion from packet-switched IP networks to circuit switched networks, but where the circuits involved are optical ones. The primary idea is that an unbroken optical circuit can be set up and sustained between two research facilities, e.g. a researcher's workstation and a remote supercomputing centre. Ideally the setting up of such a light path, including reservation of the required resources, is done automatically in response to a user request.

Both Géant and Abilene are deploying new generation networks with so-called hybrid architectures, in which a "traditional" IP network, with backbone capacities in the 10 – 40 Gb/s ranges, is overlaid by a switched light path infrastructure.

The European Commission announced its intention to build such a hybrid network, calling it Géant2, at a launch event on 14 June 2006 in Luxembourg. The press release said the new network will have a massive performance of 500 Gb/s and be a global reference for scientific networking excellence. The network will provide standard IP connections alongside switched links on some routes. The switched circuits provide dedicated point-to-point links, when needed, for the most demanding applications.

At the Spring 2006 Internet2 Member Meeting in Arlington, Va, Douglas Van Houweling, President of Internet2 announced the new backbone network that will replace Abilene, Internet2's current high-speed backbone.

The new backbone will offer roughly 10 times the bandwidth currently provided by Abilene.

Each institution will have a wavelength dedicated to conventional Internet traffic as well as a separate wavelength that the institution could use as it chooses.

3.2. IPv6 development and testing

The research and education networking community world-wide, but especially in the Far East and in Europe, is playing a key role in developing, testing and pioneering operational use of the IPv6 protocol. Abilene and Géant both support native IPv6, as do many European and Far Eastern NRENs.

3.3. Federated identities management

The Internet has enabled universities and research institutions to share each other's information resources and computing resources in new, systematic ways. This in turn led to the development of new ways of authenticating and authorizing users of shared facilities without these users having to be created and managed as users at each participating site.

Internet2 has played a leading role in developing standards and software to support so-called federated identities management. This involves an agreement between the institutions that participate in a federation that establishes the basis for each institution's trusting authentication transactions performed by the others, and it involves software that handles users' logins, seeks authentication from the user's own institution, and then applies local authorisation policies.

Internet2 has led the development of a package called "Shibboleth", which uses the Security Assertion Markup Language (SAML) specification and provides a federated, browser-based Single-SignOn and framework for exchanging security attributes. Shibboleth is being developed in an open environment and is freely available. SAML is a standard of the Organization for the Advancement of Structured Information Standards (OASIS) - see http://www.oasis-open.org/.

According to the MIT Technology Review of March/April 2006, adoption of the Shibboleth system grew rapidly in 2005, and is used at more than 500 sites worldwide, including university federations in Australia, Belgium, England, Finland, Denmark, Germany, Switzerland, and the Netherlands and China.

The federated identities approach has started moving out of academe. The science and medical division of Reed Elsevier has begun granting university-based subscribers access to its online resources through Shibboleth, rather than requiring its own specific login. A consortium of more than 150 companies and other institutions has formed a body called the Liberty Alliance that is dedicated to creating shared identity and authentication systems.

3.4. Speed records

On 26 April 2006, Internet2 announced that an international team led by Dr. Kei Hiraki of the University of Tokyo had set new Internet2 Land Speed Records in the IPv4 and IPv6 single and multi-stream categories.

The round-trip paths used by the team started in Tokyo; crossed the Pacific, traversed Canada, crossed the Atlantic to Amsterdam, then re-crossed the Atlantic, traversed the continental USA and re-crossed the Pacific back to Tokyo, covering a distance of over 30,000 kms and passing through eight international networks and exchange points en route.

The team achieved average speeds of 8.8 Gb/s for the IPv4 record and 6.96 Gb/s for the IPv6 record.

4. What about research and education networking in Africa?

4.1. The goal

As part of the World Summit on the Information Society (WSIS) held during November 2005 in Tunis, the Association of African Universities (AAU) arranged a two-day Conference on African Research and Education Networking Infrastructure. At that conference, Professor Bjorn Pehrson of the KTH, Stockholm, who is an active supporter of the REN initiatives in Africa, stated the following objective:

No later than 2008, universities and research institutions in Sub-Saharan 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 Gb/s rather than kb/s and with delays, variations and error rates as defined by normal properties of properly run terrestrial optical fibre networks.

The two most important developments for securing improved Internet access for universities in sub-Saharan Africa in the future are

the increased tempo at which national operators, cellular operators, multinational consortia of operators, and electrical power companies are ***deploying optical fibre networks*** that offer the prospect of much greater connectivity via optical fibre networks; and

the rapid emergence of ***National Research and Education Networks (NRENs)*** as the organisational vehicles for inter-institutional collaboration.

We look at each of these briefly.

4.2. Optical fibre deployment

Terrestrial connectivity using optical fibre cables is vastly preferable, in terms of capacity, communications effectiveness and cost, to connectivity that involves space segments, as is case with VSAT[1] connectivity. While many Universities in sub-Saharan Africa are still dependent upon satellite-based connectivity to the Internet, the picture is changing quite rapidly, especially as regards institutions located in or near major metropolitan areas.

Major drivers of new fibre deployments include

- the amazing uptake of mobile telephony and the needs of the mobile operators for backbone connectivity;
- the deployment of optical fibre by electrical power companies as they upgrade and extend the power grid;
- in many countries, removal of the restrictive regulations that enforced the monopoly of the historical incumbent operator (notably, this applies to most East African countries, but much less so to those of Southern Africa);
- the prospect of the East Africa Submarine System (EASSy); a submarine cable system that will run along the east coast of Africa from Mtunzini on the South African Coast to Port Sudan in the Sudan, with landing points at Maputo, Toliary (Madagascar), Dar es Salaam, Mombasa, Mogadishu, Djibouti and Mitsiwa (Eritrea), and will connect via existing cable systems to Europe and the World. EASSy was expected to come into operation in late 2007, but may well be delayed. Plans provide for all the countries of East Africa, including the land-locked ones such as Rwanda, Uganda and Zambia, to be

[1] Very Small Aperture Terminal

part of the "EASSy hinterland" - the region that is connected via optical fibre to an EASSy landing point.

From the beginning of 2008, growing numbers of universities and research institutions in Eastern and Southern Africa will be able to enjoy fast, terrestrial connectivity to each other, to RENs in other parts of the World, and to the Internet generally. This will apply soonest to institutions in or near to major cities, which means that *from early 2008, many if not most of the region's major universities and research institutions will be finished with VSAT connectivity.* Some institutions will not benefit as early as others, and institutions in remote areas may well be dependent on VSAT connections for several years longer.

4.3. The emerging NRENs of Africa

The NRENs of Europe are the prototypes for collaborative networking between and for universities and research institutions in Africa. There is a flurry of activity in the region to form NRENs. Each needs to be a not-for-profit organization characterised by:

- its national character;
- its *inclusiveness* - i.e. its acceptance of all universities and research institutions in the country (other than perhaps, for-profit and/or foreign-owned institutions) as members; and
- its primary purpose of taking responsibility for organizing inter-institutional connectivity for its member institutions and providing shared connectivity for these institutions with other NRENs world-wide.

National RENs (NRENs) already exist in Kenya and in South Africa. Active projects to establish NRENs are underway in Botswana, Mozambique, Malawi, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe.

As optical fibre connectivity becomes more and more available, each African NREN will be running a growing terrestrial backbone, to which an increasing proportion of its member sites connect. Clearly the NREN is well placed to assist its member sites to plan and prepare for their eventual connection to the NREN's terrestrial backbone, and the concomitant termination of VSAT services. *NRENs that include all of their countries' universities and research institutions and provide VSAT services to those member sites that still need them will be especially well positioned to manage the migration to terrestrial connectivity for their country's institutions collectively.*

4.4. The UbuntuNet Alliance for Research and Education Networking

The UbuntuNet Alliance for Research and Education Networking is an association whose mission is to deploy and operate a regional REN for sub-Saharan Africa. The Alliance is incorporated as a non-profit, non-governmental association in the Netherlands. Its Articles of Association ensure that representatives appointed by its member NRENs control it collectively through a Board of Directors.

The UbuntuNet network will start with a focus on areas of eastern and southern Africa where the prospect of optical fibre connectivity is greatest. Eventually UbuntuNet will inter-connect NRENs in the region, from the Sudan and Somalia in the North to Mozambique and South Africa in the South, and will provide shared, high-speed connections to Géant and to the global REN generally. Subsidiaries will be established in countries of the region as and when operational needs require this – for example to secure telecommunications licenses.

The formation of the UbuntuNet Alliance was announced at the 2005 World Summit on the Information Society in Tunis. It has received active support from the e-Africa Commission, the Association of African Universities (AAU), the Southern African Universities Association (SARUA), the European Commission and the World Bank Institute, and from major donors

such as IDRC (Canada), BMZ (Germany), the Open Society Institute (OSI) and SIDA (Sweden).

The UbuntuNet Alliance is trying to become a member, in some suitable sense, of the EASSy consortium, so as to secure access at wholesale prices to bandwidth on the cable. In November 2005 this strategy was aired in Tunis at the World Summit on the Information Society, and received some publicity. So far the consortium has declined to enter into any dialogue with the Alliance. It is important to note that the purpose of the Alliance is not thwarted if it fails to become a member of the consortium. The purpose is to be an effective regional REN for its member NRENs, as stated in the above bullet points. Becoming a member of the consortium is one possible means to this end, but it is not the sole means, and it is not the end itself.

A key challenge facing the UbuntuNet Alliance in building out its regional backbone is that of overcoming the common practice by incumbent operators of charging exorbitant prices for cross-border half-circuits.

The idea of a West African Regional REN was mooted in January 2006 at a conference in Dakar, Senegal. This will provide connectivity to Europe via the SAT-3 WASC cable when bandwidth on that cable becomes more affordable. In this regard, it is important that the "exclusivity period" granted by the SAT-3 consortium to national incumbent operators ends on 18 April 2007.

4.5. The role of donors and funding institutions

Many publicly funded and privately endowed donor organisations actively support higher education institutions in sub-Saharan Africa in a great variety of ways, including assisting the institutions to develop their campus networks and Internet connectivity. The list of such benefactors includes, but is not limited to, the following organisations of whose involvement the writer is aware: The Andrew W Mellon Foundation, The Carnegie Corporation of New York, The Ford Foundation, The Rockefeller Foundation, the John D and Catherine T MacArthur Foundation, the William and Flora Hewlett Foundation, the Bill and Melissa Gates Foundation, (all seven of which are private American foundations), the International Development Research Centre (IDRC, Canadian Government), The Open Society Institute (OSI), the World Bank Institute, the Swedish International Development Agency (SIDA), the Bundesministerium für wirtchaftlische Zusammenarbeit und Entwicklung (BMZ, German Government) and the European Commission.

The first six foundations listed above jointly constitute the Partnership for Higher Education in Africa, which provides a level of coordination of activities without reducing the independence and accountability of the individual foundations.

The emerging national and regional RENs of Africa need the support of all parties that wish to see the universities and research institutions of sub-Saharan Africa as well connected to the Internet as their counterparts in Europe and America are. In particular, funding agencies that sponsor and support connectivity development for the benefit of education and research are encouraged to shift their focus from the level of selected individual institutions to that of the NRENs and the regional RENs. The writer believes that agencies should establish primary developmental relationships with the NRENs, and should encourage NRENs to welcome all bona fide universities and research institutions in their countries as members. Wherever possible, agencies should leave the management of connectivity relationships with the institutions to the NRENs irrespective of whether the institution requires terrestrial or VSAT connectivity.

The approach described above has many advantages. One is that it promotes the inclusiveness of the NRENs by providing a direct incentive for institutions to join the NRENs even while they still require VSAT connectivity. The advantages of scale are immediate – NRENs as “bandwidth consortia” will negotiate on behalf of all institutions in their countries.

Better still, when regional RENs negotiate with network operators, including VSAT providers, they will be representing most of the universities and research institutions in sub-Saharan Africa.

4.6. The roles of Internet industry players

It is most important that NRENs and Internet Service Providers understand and respect each other's roles and interests. Insofar as NRENs act as bandwidth buying consortia, they concentrate the market and so potentially remove business for some ISPs, especially smaller ones.

In this regard it is vital that NRENs should "stick to their knitting" – i.e. should never provide services to organisations that are not bona fide non-profit universities or bona-fide non-profit research and support organisations. Subject to NRENs' compliance with this dictum, NRENs expect to be able to secure special "holy cow" deals that make sense to the NREN and to the service provider.

NRENs are frequently active at the bleeding edge of networking technology, and can benefit from close technical relationships with active ISPs as regards the testing of new protocols and services. Such projects might include, for example, IPv6 test beds and multicast protocols.

Finally, NRENs need lots of bandwidth. Whenever and wherever a new communications link is being built, or an existing one is being upgraded, the opportunity for extra fibre, or extra wavelengths to be installed and made available to the local NREN, should be considered. NRENs can often secure one-off capital contributions from donors to cover the additional deployment costs involved.

4.7. What is needed of governments in the region?

The development of successful NRENs and regional RENs in sub-Saharan Africa is very dependent upon governmental support, at national and regional levels, as regards both finance and the formal legislative and regulatory environments. Specifically, the writer believes that governments, in their actions to develop and regulate communications, education, science and technology should

- Explicitly recognise the importance of higher education and research in national and regional development plans;
- Explicitly protect and enable high-speed communications networks, within individual countries, across borders, and via submarine cables, in legislation and in telecommunications regulations;
- Regulate and even legacy demolish telecommunications monopolies;
- Dliberately promote private investment and commercial competition in telecommunications markets;
- Provide direct financial support for national and regional research and education networking associations (NRENs), without forcing top-down governmental ownership and control on such NRENs.

5. A short update on TENET

What is TENET? TENET is a non-profit, Section 21 company that is controlled by the public universities of South Africa and acts as the formal vehicle through which some 40 universities and research institutions, with 98 campuses or sites between them, procure Internet access services. TENET was created for this purpose, and may not allow entities other than educational institutions and research and support institutions to participate.

ISPA and TENET: TENET is an honorary member of ISPA, and invites ISPA to nominate one Director of TENET. ISPA's current nominee is Mr Hillel Shrock. ISPA's recognition of TENET's special nature; ISPA's willingness to engage with TENET, to assign a senior ISPA leader to participate in TENET's Board, and to allow TENET to participate in its activities are all deeply appreciated.

Some numbers: TELKOM SA provides the services in terms of a major contract with TENET. Site connections to the Backbone network vary from 128 kb/s to over 20 Mb/s for the connections to the Main Campuses of large universities. Some 70% of traffic carried across the backbone network comes from or is destined for foreign networks. When TELKOM commissions the latest batch of upgrade orders, the TENET institutions will be using some 175 Mb/s of dedicated bandwidth on the SAT-3 submarine cable. Inbound international traffic sets this requirement: outbound international traffic peaks at around 60 Mb/s.

Aggregate peering traffic with other South African networks peaks at about 45 Mb/s inbound and 35 Mb/s outbound.

The monthly charge from TELKOM SA, all told and including VAT, is around R7 million, all of which derives from the user institutions themselves – there is no direct government subsidy, and never has been one.

Inter-connection agreements with Abilene and Géant: TENET enjoys a direct transit relationship with the Géant network in London, and through Géant, with the NRENs of Europe and the World generally. TENET also enjoys a direct transit relationship with Internet2's Abilene network in New York City. Both of these connections are achieved using GRE tunnels through TELKOM's IPNet infrastructure, with BGP sessions running directly between the TENET international gateway router in Bellville and the Géant or Abilene gateway in London or NYC as the case may be. These connections with Géant and Abilene are currently the only such connections from sub-Saharan Africa.

The TENET Beachhead Facility: TENET owns and operates a facility called the Beachhead, which TELKOM hosts in Bellville in terms of a separate hosting contract. The Beachhead hosts some mundane equipment like TENET's DNS server and web-server. More exciting are the relatively new ***mirror site*** (see http://mirror.tenet.ac.za), which is already one of the largest mirror sites in Africa, and the ***IPv6 tunnel broker***.

The mirror carries a large variety of open source material, including the entire MIT Open Courseware offering and important open source software distributions. Access to the mirror is unrestricted.

The IPv6 tunnel broker brokers IPOv6 connections between TENET user sites that want to experiment with and use IPv6 and a number of international IPv6-enabled networks, including OCCAID, Géant and Internet2.

Evolutionary direction: At present TELKOM SA handles all operational aspects of the Internet access service enjoyed by the TENET institutions. The next generation of TENET service will see TENET taking operational control of its own national and international routing, peering and transit agreements, while having the appointed service provider handle all operational aspects of the domestic network. The peering arrangement with Abilene in New York, which entails a dark-fibre service contract in NYC between TENET (i.e. not TELKOM) and the New York State Education and Research network (NYSERNeT), as well as TENET's control of the Beachhhead Facility, anticipate this development.

Administration of ac.za: TENET continues to administer the ac.za domain, reporting in this regard to the ZA Domain Name Authority.

Local Internet Registry: TENET is a local internet registry (LIR), reporting in this regard to AfriNIC. The IPv4 prefixes 196.21.0.0/16 and 196.24.0.0/16 and the IPv6 prefix 2001:4200::/32 are allocated to TENET. These prefixes are announced as part of TENET's

AS's. Consequently TENET makes assignments from these prefixes only to participating institutions, and such assignments are not portable.

Capacity development programs: TENET runs a number of important capacity development programs. These comprise:

- the Development of IT Capacity in Higher Education (DITCHE) program;
- the program on Bandwidth Management and Optimisation ("the Partnership program") , managed on behalf of the Partnership for Higher Education in Africa; and
- the Fostering Research and Education networking in Africa (FRENIA) program.

The DITCHE and FRENIA programs are funded by generous donations from the Andrew W Mellon Foundation, while the Partnership program is funded by the Partnership for Higher Education in Africa (see 4.5 above).

The DITCHE Program is aimed at nurturing a distinctively African community of practice among IT professionals in our universities, both nationally and elsewhere in sub-Saharan Africa. Major activities in 2006 included a national event for library IT staff, held in May in Port Elizabeth. The next event was in June, jointly with Microsoft South Africa, on Microsoft Security and Patch Management.

The Partnership program started in 2006 with events on web caching, in Nairobi; on Open Source Traffic Shaping tools, in Johannesburg; and on Acceptable Use Policy, also in Johannesburg. An ongoing partnership with INASP made it possible to maximise joint effort of the two organisations.

The FRENIA program is funded mainly by The Andrew W Mellon Foundation and, to a lesser extent, by TENET itself. FRENIA is being launched through a series of visits to individual teams that are setting up NREN in various countries of sub-Saharan Africa.

6. Conclusion

African research and education networking is entering a very exciting growth phase that will make demands on the institutions, the emerging NRENs of the region, the owners and providers of infrastructure and services, and on governments and regulators.