FEAST Project

FINAL REPORT

Contract number: CPP No40A/2008/S 8-065628

Project acronym:

FEAST

Project title:

Feasibility Study on the AfricaConnect Initiative

Project website:

www.feast-project.org

Funding Scheme:
Period covered: from 2008-12-16 to 2009-12-16
Coordinator: Björn Pehrson
Title and Organisation: Professor, KTH, Stockholm, Sweden
Phn: +46 70 625 6140
Fax: +46 8 751 1793
E-mail: bpehrson@kth.se

SEVENTH FRAMEWORK PROGRAMME

Executive Summary

To be able to fulfil their missions, African research and higher education institutions need access to the global research and education network infrastructure. Unlike their peers on other continents, most African institutions do currently not have such an access.

Within the partnership on Science and Technology, the African and European Union Commissions have given highest priority to the AfricaConnect initiative as an early deliverable with the objective to support the African research and higher education institutions in their effort to get access to this resource, which is a requirement for the development of knowledge societies. An emerging terrestrial broadband communication infrastructure seems to offer opportunities for African institutions to join.

This one-year feasibility study for AfricaConnect, FEAST, was commissioned by EC late 2008 to explore the feasibility of deploying a regional backbone connecting dedicated National Research and Education Networks (NRENs) in Africa to each other and to their peers on other continents via GÉANT, the pan-European research and education network backbone. The study has been carried out by KTH as main contractor and DANTE and TERENA as subcontractors. The research leading up to the findings has been conducted via physical visits, workshops and email discussions involving policy makers, regulators, communication operators, infrastructure owners as well as faculty members, students and research and education network communities in about 30 African countries. Many of the contacts come from long-standing institutional and individual cooperation in the areas of research and education.

The feasibility has been judged by the NREN readiness, availability of a terrestrial infrastructure, the political and regulatory endorsement and commercial conditions for access to necessary resources.

Contrary to general expectations, availability of infrastructure, such as optical fibre is not any more a major bottleneck. Most universities are located where optical fibre cables are already deployed or will shortly become deployed.

Policy and regulation is mostly in principle permissive, but the awareness of the importance of NRENs and their needs is still low. The regulatory frameworks are often under-developed or poorly enforced, leading to lengthy implementation processes. Affordable access to links is an obstacle in the implementation.

The main finding is that the primary bottleneck is rather , with a few extraordinary exceptions, the readiness of the NREN communities. On a continental level, less than one third of the 53 African states have communities that are ready or reasonably ready. Another third has some awareness but still work to do to get ready. From more than one third there was no response to our requests for contact.

The African research and education network communities are de facto organised in three subregions, North Africa where there are four NRENS participating in the EUMEDCONNECT project since 2002 but not yet organised a subregional organisation of their own, Eastern and Southern Africa where Ubuntunet Alliance was formed in 2005 and now has a thrust of its own with eleven member NRENs from Sudan in the North and South Africa in the south and a partial network already up and running, and West and Central Africa where there are several NRENs under formation, but not yet quite ready, and a task force with the mission to establish a regional organisation, WACREN, that can be expected to be launched during 2010.

The markets for broadband links are with few exceptions not yet competitive and the operators need time and push to transform from high price-low volume to low price-high volume business models. Incentives provided by the policy makers and regulators to drive the transformation would be very useful. The neutral research and education networks can play important roles in this process, just as on other continents.

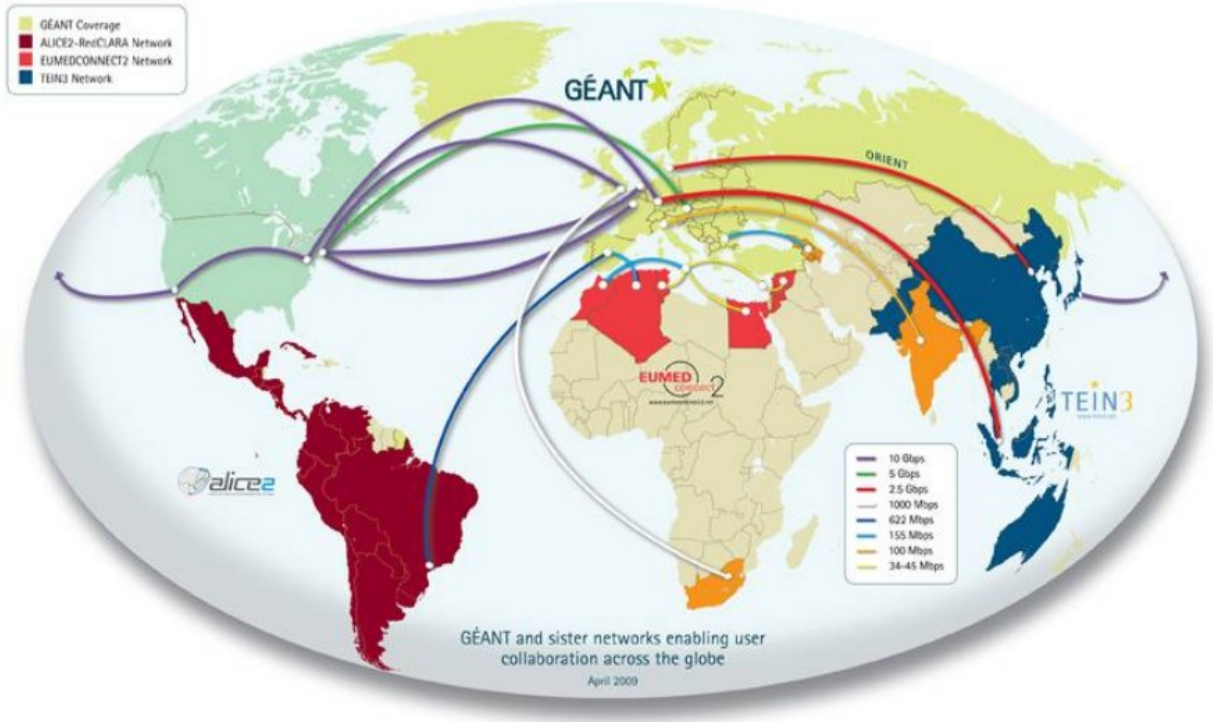
The conclusion of FEAST is that it is feasible to connect several ready African NRENs to each other and to peers at other continents via GÉANT as part of the AfricaConnect initiative by reinforcement of the emerging regional network, Ubuntunet. There is a latent demand from research and higher education institutions in Africa and Europe suffering from the lack of means of communication. There are enough African NRENs that are ready to be connected in a first phase during 2010. Preliminary discussions have indicated that it would be possible to fund the required resources over a period of three to four years with the suggested 15 M€ budget, including 12 M€ from EC and 3 M€ from the beneficiaries. Ubuntunet Alliance its member NRENs are the obvious regional partners in this first phase.

In order to take advantage of the existing momentum, our recommendation is to proceed as soon as possible by forming an AfricaConnect consortium and inviting Ubuntunet Alliance and its member NRENs as partners and/or sub-contractors in that consortium. At the same time, it is important to support the capacity building of the not yet ready NRENs and the establishment of WACREN to prepare for a second phase. The Association of African Universities (AAU) is the obvious partner to coordinate that effort for NRENs outside the Ubuntunet Alliance.

To manage the financial risks involved,, we recommend to divide the contract for the first phase into two parts. In the first part, the African partners sign a Letter of Intent and commit a minor contribution to facilitate participation in a tendering process clarifying the capacity to be procured and the costs involved in a second part. Only after these costs are known, the African partners would have to commit and agree to carry their share of the funding to participate in the second part. The bipartite model opens up for the NRENs under formation to take advantage of the planning process in the first part and join the second part at a later point in time when it suits them best. In the second part, we recommend there is also an effort spent on launching selected demonstrator applications that can demonstrate the immediate benefits of the new infrastructure and thereby motivating further investments. We also recommend allocating some resources in the first phase to facilitate capacity building for a second phase of AfricaConnect.

In Summary, the FEAST project recommends:

- To deepen the excellent cooperation with Ubuntunet Alliance and their member NRENs by inviting them to join an AfricaConnect consortium, as partners or subcontractors, together with DANTE, TERENA and interested European NRENS, with the objective to reinforce the emerging Ubuntunet regional research and education network connecting their member NRENs to each other and to the pan-European research and education network, GÉANT.
- To exploit the momentum of the Ubuntunet Alliance by aiming for a contract to be signed in early 2010, divided into two distinct parts as described above, to ensure inclusiveness with a minimum of financial exposure.
- To continue and deepening the direct twinning between African and European NRENs .
- To ensure that resources are made available for demonstration projects showcasing the benefits of the investments made via the AfricaConnect Initiative in the reinforcement of the Ubuntunet regional research and education network, and to motivate further investments in a second phase.
- To involve the Association of African Universities (AAU) as a partner and make resources available for capacity building supporting the establishment of WACREN and not yet ready NRENs to prepare them for participation in a second phase.
- To involve African higher education institutions in capacity building to meet the expected demand also from other sectors of society, and to ensure that resources are made available for capacity building and training necessary to make AfricaConnect first phase a success and to prepare for a second phase.



Global links connecting the dedicated regional research and education networks via GÈANT

1. Introduction

To be able to fulfil their missions, research and higher education institutions, wherever they are located, need access to dedicated global research and education resources. With few exceptions, African universities lack this access, as opposed to most of their peers on other continents. This is simply due to the fact that they are not connected to the global research and higher education network infrastructure consisting of dedicated high capacity regional networks. The consequence is that research and higher education requiring such access can currently not be conducted in Africa. Since such activities constitute a significant part of the global research and higher education, Africa is not well represented in the global research community.

This is not just a matter of improving the connectivity to Internet in general. Transit to the public Internet is not enough. An equally important bottleneck is the lack of direct peering with other research and higher education networks. This bottleneck can be removed only by creating dedicated National Research and Education Networks (NRENs) connecting research and tertiary education institutions in each African country to a Regional Research and Education Network (RREN) interconnected to the peer infrastructures on other continents.

To establish such dedicated networks, the NREN and RREN organisations need access to links. This has until recently been a major obstacle for the African institutions. At the same price as African universities currently pay for VSAT transit links to the public Internet only, with low bandwidth and high delay, universities on other continents get dedicated networks with 100 times higher bandwidth or more, much lower delay and **both** transit to Internet in general via commercial transit **and** peering with the dedicated networks established by the global research and higher education community.

The opportunities are there, however, in terms of new intercontinental submarine cables with abundant capacity and emerging regional and national terrestrial fibre optic backbones. This new infrastructure is in most cases in principle available as far as the national communication policies and regulations are concerned. In practice, there are still challenges, in terms of commercial conditions for getting access to the links necessary to build dedicated networks, even ii they are non-commercial and for public good. These challenge can only be taken on by negotiations and advocacy emphasising the benefits for all sectors of society to get dedicated research and education networks established as soon as possible.

Making the transition from own narrowband satellite links to the Internet to a joint dedicated terrestrial infrastructure requiring concerted efforts involves a challenging shift of paradigm. The awareness and readiness to take advantage of the opportunities is, however, growing and the research and education networking communities are coming together in an increasing number of countries to form national and regional bodies facilitating the inevitable cooperation. The first regional organisation in Africa, Ubuntunet Alliance, emerged already in 2005 and has grown to eleven members in Eastern and Southern Africa. A second organisation covering West and Central Africa is being discussed and expected to be launched in 2010.

The creation and development of regional and national research networks in Africa and the increasing capacity for international research cooperation means that it is important to investigate the feasibility of a direct interconnection of the dedicated networks in Africa and Europe. The African and European Union Commissions have given highest priority to the AfricaConnect initiative, the first of 19 projects in the Lighthouse programme in the 8th AU-EU Partnership on Science&Technology [Lighthouse FEAST] as an early deliverable with the objective to support the African research and higher education network communities in their effort.

After a review of the study terms, the study team and methodology used in the study, we will provide a summary of the fact finding, analysis, roadmap and dissemination activities that have been conducted and completed and elaborate on our conclusions and recommendations..

1.1 The study

The Feasibility Study for African – European Research and Education Network Interconnection (CPP No40A/2008/S 8-065628) – FEAST - is a European Commission funded feasibility study to evaluate the possibility of a direct interconnection between the pan-European research network GÉANT and similar activities in Southern and Eastern Africa. In agreement with EC and with the support of AAU, the study team extended the objectives to cover all of Sub-Sahara Africa.

The project was originally supposed to last 10 months, beginning in December 2008. In September 2009, the project was extended until mid December 2009 to better synchronize with key events and to make better use of the project budget. The extension of the contract did not change any of the due dates for the deliverables, except for the final report.

1.2.Study team

The feasibility study has been conducted in partnership by KTH, DANTE and TERENA, with KTH as main contractor and DANTE and TERENA as subcontractors. The partners have built on their complementing expertise and experiences in Europe, Africa and in regional development programmes:

- DANTE is a UK based not-for-profit organisation mandated by the European national research networks to organise, build and manage international networking services on their behalf and .has successfully also coordinated all previous EC-funded regional development projects outside Europe.
- KTH is a Swedish public university with many African MSc and PhD students , well connected with relevant African institutions and projects and experienced in development and operation of research and education networks networks in the Nordic region.
- TERENA is an association of European NRENs and has contributed to the development of African NRENs and involved the European NRENs in this work using a twinning concept.

We gratefully acknowledge the volunteer support offered by several other organisations, including the International Centre for Theoretical Physics (ICTP), the Ubuntunet Alliance and African NRENs as well as several European NRENs that have earlier experience from working with DANTE in the implementation of other regional networks. A special thanks to Ubuntunet Alliance and the German NREN DFN for their generous contributions.

1.2 Methodology.

The study was organized in four parts 1) Fact finding 2) Analysis, 3) Roadmap and 4) Dissemination.

Fact finding

The fact finding was led by KTH and is accounted for in deliverable D2A. It was organised into four categories: a) Readiness of the research and higher education network communities, national and regional, b) Availability of infrastructure in terms of links and supply chains, c) Policy an regulations controlling research, higher education and communication, and d) The maturity of the communication markets, including competitiveness and commercial conditions for getting access to the links and equipment necessary to build NRENs and RRENs.

The research leading up to the findings has been conducted via physical visits, workshops, questionnaires and email discussions involving policy makers, regulators, communication operators, infrastructure owners as well as faculty members, students and research and education network communities in about 30 African countries. Many of the contacts come from long-standing institutional and individual cooperation in the areas of research and education

Physical visits have been paid to all the East African countries except Burundi, i.e. Kenya, Uganda, Tanzania and Rwanda. Among the countries in the Southern African Development Community (SADC), Malawi, Mozambique and Mauritius have been visited. In West Africa (ECOWAS). Benin, Ghana, Nigeria and Senegal have been visited.

During some of these visits, there have been stand alone meetings or sessions part of other conferences or workshops organised by the FEAST team, providing opportunities to meet the research and education networking communities also in other countries than those directly visited. The stand alone workshops include meetings with the Ubuntunet members in the Southern cluster in Maputo and Eastern cluster in Dar es Salaam. Sessions part of other events include IST Africa and UbuntunetConnect in Kampala, the Open Access conference in Accra, AAU workshops on WACREN in Dakar and Accra. Policy issues have been discussed at a CAAST-net meeting in Mombasa.

Analysis

The objective of the analysis was to find viable alternatives for design of an African RREN focusing on the the most ready sub-region covered by the Ubuntunet Alliance and its members, led by DANTE and accounted for in deliverable D2B. As a part of this activity FEAST addressed potential providers to survey the options for connectivity with Ubuntunet Alliance member NRENs and towards Europe. In this respect, FEAST posted a Request for Information (RFI) to 24 African national operators and 13 international providers of connectivity asking them for an outline of their services within and between the sub Saharan African region and Europe. A key issue for the interconnection is to have a single point of presence within Africa from which all research networks in the region can be reached.

Roadmap

A roadmap towards successful implementation of the RREN and its interconnection to GÉANT, outlining in detail the necessary steps to be taken in preparation of the AfricaConnect project and during the initial phase of AfricaConnect. This part was led by DANTE and the roadmap is summarised in deliverable D2C.

Dissemination

Dissemination activities to raise awareness of the study and its findings via workshops and brochures. The dissemination activities were led by TERENA and are accounted for in the deliverables D2D-1, D2D-2 and D2D-3. FEAST organised various workshops both in Europe and in Sub-Sahara Africa, to raise awareness of the project and its findings, and to prepare Ubuntunet Alliance and its member NRENs, as well as the European partners for participation in the follow-on AfricaConnect implementation project. The workshops generally brought together the representatives of the AAU, Ubuntunet Alliance and its member NRENs, European NRENs and the European Commission to debate the project, its objectives and future plans.

2. Readiness of the research and higher education communities

The establishment of a research and education network infrastructure in Africa, similar to what universities on other continents have access to, will require a transition from satellite links to terrestrial networks. This transition is not trivial. It will require extensive cooperation between institutions, substantial capacity building of human resources as well as investments in facilities, such as campus networks, access to new and capable local access networks, national and regional backbone networks connecting to intercontinental links.

The FEAST method to assess the readiness concurs with regionally developed models [Greaves]. The first prerequisite is that there is an awareness and demand from the research and higher education institutions and national as well as (sub)regional organisations having the capacity to meet this demand. The main parameters used to judge the awareness and readiness are discussed below

2.1 User needs and requirements

During our interviews with policy makers and regulators, we have sometimes met a lack of understanding of the needs of the research and higher education communities beyond a bit faster email and web access to the public Internet.

We have emphasized that the needs are national, not only individual or institutional. Access to dedicated high performance research and education networks is necessary if the nation wants their research and higher education institutions to be able to fulfil their missions. It has been shown in other parts of the world that growth in the deployment of the Internet is mirrored in an increase in economic development of the nation.

Failing to provide such network resources will make the institutions fall behind, incapable of participating in most international research areas and cause frustration leading to brain drain.

The FEAST study has identified a few Lighthouse Demonstrators providing examples of end-user applications that are just waiting for better connectivity and could start operating as soon as the institution at which the researchers are located get connected to their NREN connected to a regional network connected to the world.

Such applications are important in order to demonstrate immediate success of the investment made so that the investors are willing to provide the necessary funding to connect more ready NRENs.

Two such examples are

1. The Malawi-Liverpool Wellcome Trust Malaria Genome project at the University of Malawi College of Medicine in Blantyre could immediately start sending the data collected from DNA samples of persons with Malaria for analysis by their partners in Liverpool via the network rather than via hard disks. They will even be able to do the analysis on-line and speed up the research cycle substantially.

2. The High Performance Liquid Chromatography (HPLC) laboratories set up at Makerere University in Kampala and MUHAS in Dar es Salaam in cooperation with Karolinska Institute in Stockholm can be used to find faked drugs and monitor drug concentration in the blood stream of the patient under treatment. The laboratories would become more efficient if connected to each other to facilitate cooperation on interpretation of measurements, and to the technical maintainers to reduce travelling costs.

The ERINA4Africa project is gathering more examples like this and the eIAfrica project is spreading awareness of the importance of e-infrastructures like these to policy makers.

2.2 Campus data networks and services

The ultimate purpose of research and education networks is to provide services to students and faculty members empowering them to do research, teach and learn on advanced levels. The establishment of an appropriate infrastructure to accomplish this requires an institutional awareness and leadership.

The quality of campus networks and connections between NREN members are consequently both important readiness parameters. This is a matter of awareness and dedication of the institutional leadership.

2.3 NREN readiness

On the national level, there needs to be an NREN organisation recognized by the research and higher education institutions in the country.

The organisation and its plans should be endorsed by the relevant policy making ministries and regulators. The organisation needs to be properly staffed to handle both administrative and technical matters and to have the capacity to negotiate connectivity deals on behalf of their members. The human resources need to include directors, a business administrator and system and network administrators.

2.4 Subregional organisations

The development of research and education networks in Africa is de facto divided in three subregions:

1. The North African states are participating in the EUMEDConnect project [EUMEDConnect] since 2001. The establishment of a sub-regional network owned by the states in the North-African sub-region is being discussed but has not yet happened.

2. In Eastern and Southern Africa, the Ubuntunet Alliance was formed in 2005 [Ubuntunet]. The Alliance now has ten full members and a few more pending members. Discussions are in progress between the Ubuntunet Alliance and DANTE to prepare for cooperation on regional connectivity and capacity building in the AfricaConnect initiative.

3. The ECOWAS and CEMAC member states in Western and Central Africa cooperate in the WACREN community, the formalisation of which is endorsed by the involved Vice Chancellors and is expected to happen in a near future.

The regional networks are necessary to manage the complexity of the global infrastructure and to facilitate peering agreements keeping regional traffic regional within the continent.

2.5 Acceptable Use Policies

In order to promote proper use of resources and not to be perceived as commercial operators, the regional and national research and education networks need to publish Acceptable Use Policies (AUP) and a Connection Policy (CP) stating that the purpose of the network is to serve non-profit research and higher education institutions and nothing else. The policies need to be enforced by excluding violators for several reasons: One reason is to make a clear statement that NRENs are not competitors on the commercial communication market. Commercial conditions for leased network capacity routinely demand this if NRENs and RRENs are going to be in the forefront of the transformation to a high volume - low unit price market also in Africa. Another reason is that the policies of similar networks in the rest of the world need to be mirrored. The adoption and publication of an AUP and a CP is thus one of the prime prerequisites.

2.6 Assigned numbers

In order to design dedicated IP-networks, there is a need for provider independent assigned numbers including IP-address space, both IPv4 and IPv6, and AS-numbers. In Africa such numbers are provided via AfriNIC. Normally they are handed out on an institutional level. There is a need for national and regional coordination to avoid fragmentation and to optimize routing table sizes. To accommodate this, there is an agreement to delegate number series to NRENs as Local Internet Registries (LIR).

The implementation of this process of providing assigned numbers has been terribly slow. Due to the potential delays involved in each step, the status of the applications for assigned numbers for the regional national and institutional networks is another key readiness parameter.

2.7 Network Design

The next step towards an operational network is a network design and procurement documents for links and network elements. The existence of such plans is an important sign of readiness.

2.8 Political endorsement

The concept of dedicated research and education networks, developed in the form of a bottom up user driven cooperative process, is at times unexpected and its potential poorly understood by ministries of research, higher education and communication. The culture is often top down, in particular where a competitive communication market is not yet developed. All stakeholders need to be brought into the picture.

The concept of research and higher education institutions being customers wanting to lease links and establish dedicated networks, with more capacity than until recently was more than the whole country was using, can lead to confusion. Not least among persons in and around the incumbent telecommunication operator, initially perceiving it as competition, but then as loss of easy business, as they would like to sell fractions of the capacity, with high contention ratios, to universities at elevated value-added prices.

Endorsement and required permits/licenses from the national regulator are informally no doubt influenced by this. Formally, in the cases where the regulator is clear over its role and has a reasonable legal framework, this is less of a problem as long as the RENs are non-commercial, serve a closed user group of research and higher education institutions and lease dark fibre or capacity between nodes from licensed operators rather than deploy owned physical infrastructure. In most cases, NRENs would not be likely to deploy wire-line infrastructure outside campus areas at all [TERENA].

2.9 Access to infrastructure

Operators are normally not equipped to immediately meet the demand of NRENs that want to get access to resources on the same level as their peers on other continents. However, the rapid transformation envisioned by operators as they get exposed to the changes provided by international fibre links and national backbone loops creates less of a problem with this group if solutions to manage the transformation to high volume low price state are helped by positive actions with the NRENs. A challenge they face is to accept and embrace the idea that universities will not be the residential type of individual customer of managed bandwidth that they may have hoped for.

The availability of affordable leased lines and modern relevant ICT supply chains are likely to develop at the same pace as a Telecom policy supporting sharing of infrastructure and competition on services. Commercial funds in combination with soft loans to deploy backbones reaching most cities with key universities seem to be increasingly committed also in less dynamic telecommunication markets. The major remaining problem of affordable access seems to be backbones to more remote university towns and the local access there.

3. Infrastructure

3.1 Campus networks

Starting from the end-users, the transition from a satellite-based infrastructure to a terrestrial network is a challenge in many ways. In order to benefit from substantially higher capacity and direct access to academic peers via dedicated networks, former VSAT gateway owners in next door departments have to pool resources with neighbours and hand over full control of their own, but narrow and expensive Internet connection provided by a commercial operator on another continent, to a local IT-department.

From an infrastructure point of view, the deployment of campus networks is mainly an awareness challenge since they do not involve Right of Way issues. The main requirement is a dedicated institutional leadership that sets aside the necessary budget for infrastructure, servers, clients accessible for users and an adequately staffed ICT service. The passive infrastructure should consist of optical single mode fibre cabling between optical distribution frames (ODF) in wiring closets in each building on campus and twisted pair cabling to outlets at all locations where the network should be accessible via wired and/or wireless access points. The active infrastructure should consist of switches and routers with future-proof Gigabit Ethernet (10/100/1000 Mbps) ports.

A majority of the institutions we have been talking to have deployed, or are in the processing of deploying, such networks, although you could often wish they had more powerful computers available for end-users.

The campus network has to include a network operation centre supporting performance and security monitoring, trouble shooting and active enforcement of the Acceptable Use Policy [bwmo].

3.2 Local access links

Continuing upstream from the campus network gateways of the NREN member institutions to the national hub(s) of the NREN, the local access networks constitute the most severe bottleneck.

Surprisingly few of the larger cities, where most of the key research and higher education institutions are to be found, have a metropolitan area network in which the institutions can lease dark fibre or affordable broadband capacity. This is, in many countries, now the main bottleneck.

As an example, the incumbent in Tanzania, TTCL, say they have too little fibre in their metropolitan area network in Dar es Salaam to lease dark fibre and as a consequence quote astronomical prices for capacity to cross a street. The institutions initially therefore plan to use wireless links to connect their campuses to the NREN.

In Maputo, there is at least some competition, since both the incumbent telecom operator and the parastatal power utility company have fibre to lease in the city and the institutions are discussing the establishment of Maputo Gigabit Network connecting them.

Several of the incumbent operators have a thin end-user base, often just a few percent of the user base of the mobile phone companies. If the latter become full service houses, a road they have embarked upon, the

incumbent operators will be even more subject to competition in the backbone business and servicing broadband to major commercial users. The traditional landline telephone (POTS) business will be hard to protect and is likely to fade away. ADSL will have strong competition from mobile broadband 3G and HSDPA installed by GSM operators, LTE is just around the corner and WiMAX will be an alternative from other providers, and also as broadband capacity enhancement from GSM operators.

The relative scale advantages of the wireless operators over the former incumbent operator with its sparse wire-line footprint, combined with environmental factors like population demography, purchasing power and use habits, will most certainly create sets of surprisingly different market dynamics in African markets.

The Cable-TV networks are small and virtually non-existent as viable competitors outside the more affluent areas in the capital. They are likely to try to maximise their leverage of any existing plant by introducing DOCSIS3-based broadband, but the numbers will likely be small.

However, all of the various new and legacy networks will increasingly deploy or rent, if available, optical fibre based capacity in their "middle mile" sections of the local access network. In this respect they will not differ from the strategies deployed elsewhere in the world. There will be a combination of demand, distance and capacity factors driving the fibre further out in the various networks. We will, just as in more developed markets, need fibre to the neighbourhood (FTTN). The question is just at what rate and what the most influential factor will be.

Fibre to major mobile phone base station sites is already a 3G business planning reality, also in Africa, even if implementation is held back not of financial but more Right of Way and legal reasons.

3.3 National links

Before summarising our survey of national fibre backbones, we will discuss the market development in general.

General development of the fibre market

Initially, access to the new infrastructure will be offered in and immediately around the capital city and perhaps a few other major commercial centres. This needs immediately to be complemented with national backbone links to all district centres in the country and, likely in a second more time-consuming phase, to all towns. The expansion could be looked upon as a step by step refinement of a hierarchical network structure between the points reached by international cross border links all the way down to the local access network. For illustration purposes it could be useful to look at it as a two layer structure even if it could take other forms. The initial coarse grid will very likely be connecting all the major district centres just due to the fact that they are district centres; concentrations of commercial and administrative centres and the obvious immediate commercial base for any new demanding communication services.

There is also an important link to the electrification programs in the countries already at this level. The district centres are the first ones to be reached or upgraded by electrical power high voltage transmission lines requiring optical fibres built into the grid just to control the electrical transmission system. There is unfortunately a little understood and appreciated intersection here between the power and communication industries. The cost of adding more fibre strands than the few pairs needed for the control system to the optical fibre-carrying core tube of the grounding wire between pylons, is marginal. This is by far the most simple, fast and cost effective way of making any fibre backbone available in any country where the power grid expansion takes place. The marginal added cost are two orders of magnitude lower than most other alternatives: In the order of USD 200 per km for an added fibre pair to USD 10000-30000 for a standalone optical fibre cable deployment.

As electrification of Africa will increasingly mean gridification of all major towns there is a strong correlation between these two activities. Anyone who has the control over the spare fibres in the power grid will have a profound influence in the National Telecom Backbone market.

However, we can notice some confusion in making this asset available from the side of the power companies. First of all, they have in several cases been prevented from at all making it available by the legal systems in the form of counter-productive licensing restrictions set up to protect the incumbent telecommunication operator at all costs. Secondly, most power company executives have had little or no appreciation for the dynamics in the telecommunications industry. As an example, they generally do not recognise the price elasticity as the bandwidth market turns from scarcity to abundance. This is not an African problem but was equally visible in the US and Europe as these markets opened up, fibre was introduced and prices plummeted.

Given the Right-of-Way advantage of the power companies, most countries would likely do best in recognising the position of the power companies as being associated with all the necessary characteristics needing sector regulation: Levering a monopoly position in one industry sector into a different competitive

one, with a cost base far below all alternatives are reasons enough. Donor funding into new grids needs to recognise this problem too.

Nevertheless, there are a number of ongoing projects trenching cable outside the power industry, both from incumbent telecommunication operators and new players, mobile phone operators as well as metro broadband providers. These projects have a high relevance regardless of the fibres in the power grid. There are obviously timing and footprint issues, but first and foremost control issues. With an exploding demand being foreseen, none of these companies can bet their future on a partly whimsical and unpredictable process regarding fibre being available or not in the power grids on a reasonable, fair and timely manner

There is thus going to be a number of players that would build their own buried fibre backbone links. Some will partner with competitors to get a lower cost base, some will go alone to later sell to others. There will no doubt be a number of cost sharing mechanisms increasingly adopted as players realise that the backbone transport market swings from scarcity to abundance and that this is just a non-differentiating input resource in their value creation to be acquired at as low cost as possible.

There are a number of different government interventions possible in the backbone development process. The obvious reflex is the traditional protection of the vested interests in the old, often defunct PTT, now often partly privatised, but with a clear financial interest from government anyhow. More useful approaches involve a prompt resolution of Right of Way issues, continuing by stimulation of asset sharing, going all the way to be a facilitator and part stakeholder in such activities. This is an increasingly complex route that most administrations have little or no expertise in.. It is the next structural battlefield after international submarine cable connectivity and initial cross border capacity turns scarcity to abundance on that level.

Survey of available national fibre backbones

In several countries there are national optical fibre backbone networks in service, being deployed or planned, in some countries even more than one. Several countries are supported by The World Bank in this endeavour, via its Regional Communication Infrastructure Program [RCIP] and/or Science Technology and Higher Education Program [STHEP]. Many countries have different sorts of agreements with China involving deployment of fibre and active equipment.

Arab League countries

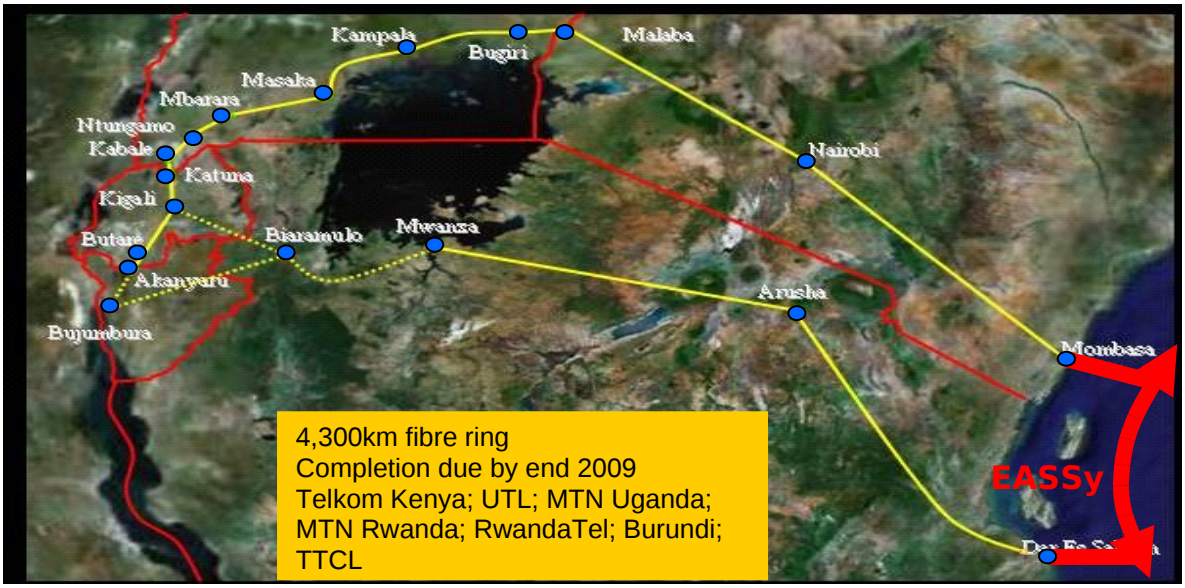
Of the Mediterranean countries, Morocco, Algeria, Tunisia and Egypt have reasonably developed communication infrastructures and operational NRENs, all participating in the EU-funded EUMEDCONNECT project. The development in Libya and Mauritania is lagging. Sudan and Ethiopia both have monopolistic incumbents deploying fibre backbones with a reasonable coverage. Somalia suffers from security problems that so far have prevented the branching point of SEACOM be taken ashore. It is currently laying idle waiting on the sea floor outside Mogadishu. There are also discussions about connecting Somaliland and Puntland via fibre to Djibouti. The Kenyan terrestrial fibre network is also growing close to Somalia from the south. SUIN in Sudan and SomaliREN are already members of Ubuntunet Alliance. Ethiopia has applied and is a pending member. Djibouti is small and well connected via many sea cables but is not yet active vis-a-vis Ubuntunet Alliance. Eritrean universities have not responded to any of our contact attempts.

EAC countries

All member countries of the East African Community have NRENs that are members of the Ubuntunet Alliance. From an infrastructure point of view, Kenya and Rwanda are the most developed with three independent owners of optical fibre infrastructure each and already operational backbones. In Kenya there is Kenya Telecom, Kenya Data Networks (KDN) and the Government of Kenya who is deploying a national open access infrastructure.

In Rwanda, there is the former incumbent, Rwandatel, MTN and the government of Rwanda via Rwanda IT Authority (RITA) including infrastructure deployed by the power utility company Electrogaz. In both these countries the NRENs are fully endorsed and actively supported by their governments and regulators.
The Government of Tanzania has been discussing a national backbone for many years based on consolidating fibre deployed in several different infrastructures, such as the power-lines, gas and water distribution pipelines and railways, but it has not yet materialized. The regulatory framework is open but the mobile operators that want to pull their own fibre have a hard time getting Rights of Way.

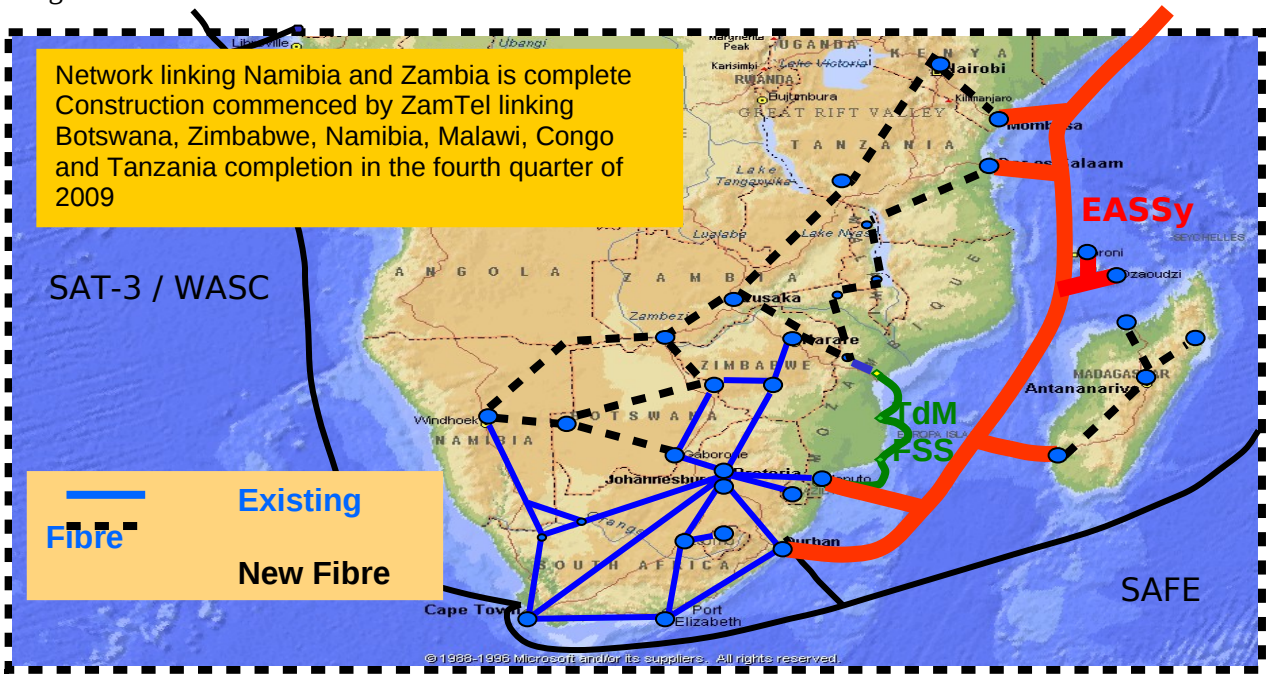
The backbone of Uganda is planned but only partly available. Burundi is behind but work is in progress.



The East African Backbone

SADC countries

All SADC countries except Comores and Madagascar have more or less active NREN communities. Regarding infrastructure, they are very different. In Malawi, the incumbent, MTL, is very active but has little competition. MTL is offering Internet connectivity at 1700 USD/Month, connected to SEACOM in Maputo via TDM, the Mozambican incumbent, who has fibre to the Malawi border. In Zambia there is operational fibre in the Zesco and CEC power-lines connected to South Africa via Namibia. Zimbabwe has enough national fibre for an NREN but is still isolated. Botswana, Namibia, Swaziland and Lesotho have the necessary fibre to establish their NRENs but are dominated both by own and South African incumbents. Angola and DRC still suffer from lack of infrastructure investments.



EASSy Southern Backhaul

The South African market, enjoying the most advanced offers in Africa, has nevertheless been one of the most policy constrained ones until the market opened up in a dramatic way after a court case late 2008 made it possible for a large number of operators to engage in infrastructure. The consequences of that change are now beginning to show in a rapid expansion, beyond all the World Cup related. It sets an example of what can be done elsewhere too. The NREN, TENET, has benefited from this too in getting competitive access to Mtunzuni and the SEACOM landing.

Indian Ocean Countries (IOC)

The Indian ocean countries , including Comores, Madagascar, Seychelles, Mauritius and Réunion (France) face special challenges due to their locations and sizes. They cooperate in the Indian Ocean Commission, which has a university development program. IOC also initiated work 2007 on optical fibre communication systems to better connect the islands and balance the distance disadvantage between the member countries. Being left out in discussions on EASSy due to the small and commercially sub critical nature of the markets, the work contains a subsidy part necessary for open Access implementation. Madagascar will be connected to EASSy as will now the Comoros due to a late decision. A consortium dominated by France Telecom plans a cable called LION between Mayotte, Madagascar, Reunion and Mauritius. In a second phase there will likely be a connection Mayotte to Mombasa. Mauritius and Réunion are already connected via SAFE. The big remaining problem is the Seychelles, which may link to Mombasa in a separate system.

ECOWAS countries

In West Africa, there is both national and regional fibre to connect the key universities, at least in the countries where there is a reasonably ready research and education networking community. Cape Verde has a fibre infrastructure covering the islands. Senegal is struggling with the incumbent regarding international connectivity but the Government has deployed a national backbone connecting the major universities. Côte d'Ivoire also has fibre close to all key universities. Ghana has a National Communication Backbone Company (NCBC) with fibre reaching all universities. Benin is well connected but lack endorsement and understanding for the need for a research and education network infrastructure. The situation is somewhat similar in Mali and Burkina Faso. Nigeria is probably one of the most competitive communication markets in Africa but has a scaling challenge connecting several hundreds of institutions, equal in magnitude to all other WACREN NRENs. Niger has few research and higher education institutions and are connected to SAT-3 but suffer from the monopolistic market structure. The Gambia, Guinea, Guinea-Bissau, Liberia and Sierra Leone have no or little activity related to research and education networking.

CEMAC countries

Central Africa is still behind. The World Bank has, however, recently announced a major investment in the whole CEMAC region [WB2009].

The most developed of the six countries is Cameroon where there is an active ministry-controlled research and education networking activity. Optical fibre is being deployed but is dominated by the monopolistic incumbent, Camtel.

3.4 Regional

Cross border links are still politically difficult to get established, the main reason being the legacy of gate-keeping policies giving landlocked countries little choice to connect but by accepting a toll from a neighbour. Access to SAT-3 from Namibia and Botswana over RSA is a classical example.

However, in a transforming market, the country with the most external connections and dynamic internal service and content market will win. Any attempt to gate-keep will be counter-productive in the longer perspective as alternative routes will be stimulated.

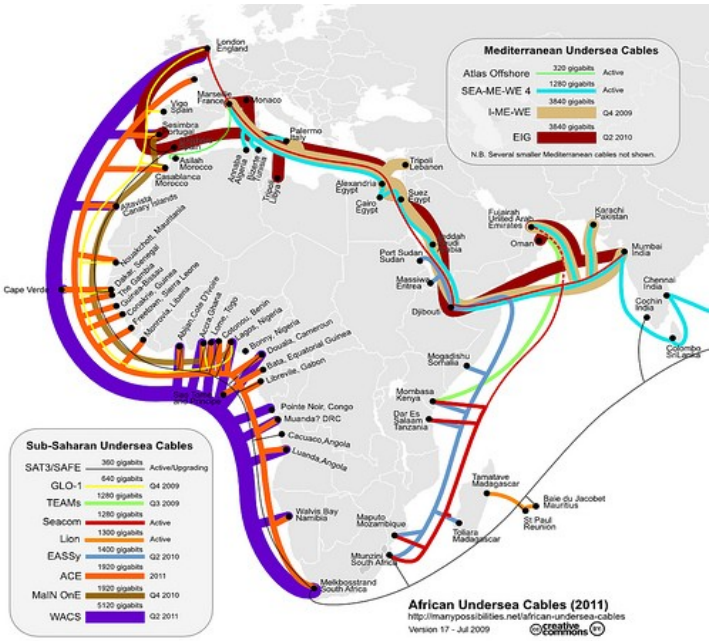
The East African Back haul (EAB) is a good example of structures that have now emerged as a consequence of the submarine cables starting to operate on the east coast. Still, it is not yet in operation even if it could have made use of SEACOM and TEAMS day one as they became operational and not wait for EASSy arriving 2010.

Some of the private operators have established metro rings which they now try to leverage by interconnecting in limited scale national backbones that they try to stretch into neighbouring countries. KDN in Kenya is a good example of that, but it also happens in Nigeria with Suburban Telecom and of course the mobile phone companies now repositioning themselves as cross border full service providers. MTN, Zain and Vodacom are all more or less into these issues, as is Orange in tying all its acquisitions and partner companies into its backbones, including regional submarine cables like LION.

Ultimately, there will be lots of terrestrial capacity also challenging quite a bit of the submarine cable capacity. The Cape to Cairo route envisioned by the 2005 collapsing Comtel project may be a reality in a different shape by 2015, likely reaching the Mediterranean on a non-Egyptian beach for redundancy reasons.

3.5 Intercontinental links

Several intercontinental submarine cables connecting Africa to other continents are planned and some are already operational.



The scarcity experienced until recently will soon be forgotten in major coastal cities. By the end of 2011 the situation is drastically different from early 2009. The bottleneck has moved from intercontinental connectivity to terrestrial back-haul backbones and access networks. Initially this creates some confusion since much of the rhetoric on elevated prices has conveniently but falsely been attributed to the cost of the international segment. Prices are initially not coming down at the rates that could be expected.

The debate over the first submarine cable on the East coast will now be followed by a debate over what cables will complement the SAT3 cable on the African west coast. Also here we will during the last months of 2009 but mainly next year see considerably more capacity coming on-line challenging the SAT-3 dominance. The regulatory situation is, however, more complex and will still confuse the conditions on which this new capacity will be made available in some markets. One can assume that this will take another one or two years to sort out. Not least will the first, still invisible, East-West equatorial terrestrial cable influence the business dynamics of the telecommunications market of the region.

4 Policy and regulation

Policy making is in this context referring to the creation of new legislation while regulation refers to the formulation of the more detailed rules that are required in the implementation phase, as well as enforcement of the rules. There are primarily two areas of policy and regulation pertinent to research and education networks, Higher education and communication.

4.1 Research and Higher education

Policy in the area of research and higher education is normally managed by a dedicated minister of Higher education, Science and Technology, while regulation is managed by independent agencies for accreditation, quality control, research funding, etc. One of the important awareness issues is whether the need for dedicated networks for research and higher education, or indeed the magnitude of connectivity discussed here, is fully recognised or more than marginally understood in all its consequential aspects.

It is not the case that this is understood in all countries studied.. On the contrary, it is in several cases a new matter that needs to be brought onto the agenda. The quality of ICT usage in the public administrations is by itself often an indication of the relative starting position for the debate.

4.2 Communication

Policy in the area of communication is normally managed by a ministry for communication, sometimes together with research and higher education. Regulation is managed by an independent regulatory agency with the role to arbitrate within and between the producers and consumers on the communication market considering the public good aspects of communication.

The important issues is whether it is de facto possible for the NRENs and their members to at least lease links from licensed infrastructure owners to deploy and operate own non-commercial dedicated networks and even get Rights-of-Way to deploy own optical fibre cables for that purpose if necessary.

Some NRENs, including KENET in Kenya and MAREN in Malawi, have licenses from CKK and MACRA respectively. MoRENet in Mozambique has a paper from the regulator INCM stating that they do not need a license to operate a dedicated non-commercial research and education network.

Even in countries where the regulatory environment formally allows this, it is not always possible to get all permits necessary to actually implement a research and education network.

5 Commercial conditions

There is an increasing number of countries that have operational national optical fibre backbones but very few of them can yet demonstrate competitive markets for broadband links. This is likely to change quite soon in those markets where the playing field is not tilted too much in favour of vested interests. The media debate is often but not always a good indicator on how far the vested interests can hold back change.

In markets where several operators complain over Right-of-Way issues you can anticipate enough commercial reason for them to venture into building metro rings and backbone spurs to and between the capital, the commercial hub of the country and the landing site of international submarine cables or border crossings. Another indicator is the way the backbone fibre in the transmission network of the Electrical Power Company is commercialised, monopolised or according to an open access regime.

6. Recommendations

6.1 Connectivity

There is a substantial momentum in the development of the African communication infrastructure in general and in the African research and education networking in particular. It is created by the opportunities that new submarine cables and emerging terrestrial regional and national optical fibre backbones provide and the work of AAU, the Ubuntunet Alliance and a few pioneering NRENs to take advantage of these opportunities to improve the connectivity of the African research and education institutions. In order to exploit this momentum, it is our recommendation to go ahead with the AfricaConnect initiative as soon as possible. An AfricaConnect consortium led by DANTE should be formed early 2010. AAU, Ubuntunet Alliance and its member NRENs should be invited as partners or sub-contractors, together with TERENA and interested European NRENs. The objective should in the first phase be to upgrade the Ubuntunet regional backbone according to the FEAST roadmap to connect all ready Ubuntunet member NRENs to each other and to GÉANT, which can provide peering with similar networks on other continents. This will not only serve the universities and research institutions, but also indirectly support a much needed transformation of the entire telecommunications market.

To manage the financial risks involved,, we recommend to divide the contract for the first phase into two parts. In the first part, the African partners sign a Letter of Intent and commit a minor contribution to facilitate participation in a tendering process clarifying the capacity to be procured and the costs involved in a second part. Only after these costs are known, the African partners would have to commit and agree to carry their share of the funding to participate in the second part. The bipartite model opens up for the NRENs under formation to take advantage of the planning process in the first part and join the second part at a later point in time when it suits them best.

6.2 Applications

A few selected Lighthouse demonstrators, like the ones discussed above, should be supported as part of the connectivity and capacity building activities to demonstrate immediate benefits of the investments made and motivate a second phase of AfricaConnect

6.3 Capacity building

When discussing capacity building, it is important to understand that the establishment of dedicated research and education networks will have an impact in all sectors of society. The students that get access to these networks will be accustomed to, able to exploit and require access to similar resources when they go into working life. Both public and private sector will need their competences and especially private sector will be able to pay better salaries and offer different challenges. The plans for capacity building need to take this into account. The experience from other markets is that system and network administrators, project managers and directors will be in high demand. The individuals will frequently move on into private sector positions and need to be replaced when moving on. This development can be expected to hit Africa as a Tsunami; once you see it, it is too late to prepare. There is a need both to reinforce the education of network engineers in general and for specific training related to the actual networks to be deployed.

Education

Few African institutions have curricula on the BSc and MSc level specializing in communication networks and need stimulation to meet the rapidly growing demand for this competence from all sectors of society as the new infrastructure becomes available. It should be considered in what form this stimulation can be provided. Ultimately capacity building will help reduce brain drain and the digital divide.

Training

Specific training necessary to make the AfricaConnect Initiative a success should be organised as part of the project itself. One of the forms for that training is the NREN twinning program coordinated by TERENA.

References

[AAU] Connecting West & Central Africa to the Global Research and Education Infrastructure, Study for the Association of African Universities (AAU) of Optical Fibre for Research and Higher Education Networks in Western and Central Africa, AAU, 2009

[BELIEF] Bringing European e-Infrastructures to Expanding Frontiers www.beliefproject.org

[bwmo] How To Accelerate Your Internet, http://bwmo.net/

[eI-Africa] eI-Africa project, eInfrastructure Summit in Africa

[ERINA] Exploiting Research Infrastructure potential in key Areas www.erina-study.eu

[EUMEDCONNECT] www.dante.net

[FEAST] Feasibility Study for the AU-EU AfricaConnect initiative www.feast-project.org

[Greaves] Duncan Greaves, An NREN Capability Maturity Model, www.ubuntunet.net

[Lighthouse] The Lighthouse programme part of the 8th AU-EU Partnership on Science and Technology, http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1442&format=HT

[OA2009] WACREN meeting and the 7th Int. Conference on Open Access, Accra Nov 2009 (www.wideopenaccess.net)

[RCIP] The World Bank Regional Communication Infrastructure Program www.worldbank.org/rcip

[STHEP] The World Bank Science, Technology and Higher Education Program

[Ubuntunet] Ubuntunet Alliance for Research and Education Networking www.ubuntunet.net

[TERENA] J.Dyer, The Case for NRENs, www.terena.org/publications/files/20090127-case-for-nrens.pdf

[WB2009] The World Bank Central Africa Backbone Program, http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:22340869~pagePK:64257043~piPK:437376~theSitePK:4607,00.html