

# Integrated development and capacity building supporting the establishment of the African Broadband Infrastructure

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## Abstract

The purpose of this paper is to propose a framework for the development and capacity building necessary to fully take advantage of the emerging African optical fiber-based communication infrastructure. Our hypothesis is that by using the universities as a neutral platform for multi-stakeholder partnerships involving all actors on the communication markets to spearhead the development, it will be possible to have Africa leapfrog into the knowledge society. We have validated this hypothesis in small scale pilots discussed in the paper and we believe that the framework used in this pilot projects is scalable.

## 1. Introduction

The Ubuntunet Alliance [UA] has recently been formed to become an association of national research and education networks in Africa with the mission to establish and operate a regional academic backbone. One of the strategic objectives in the recently released strategic plan of the Alliance is the "Enhancement of functionality and performance of African academic networks and capacity building of human resources in Internetworking and other relevant areas in the region".

One of the activities discussed to meet this objective is the Communication Systems Design Framework [OA] that can be described as a framework for problem-oriented, project-driven development and learning integrating development and capacity building. The framework facilitates cooperation between universities, public sector organizations, industry and other sectors of society in multi-stakeholder partnerships.

In the African context, the primary objective of the development part would be to establish an academic network infrastructure in Africa comparable to those available for universities on other continents, such as Géant in Europe, Internet2 and CANARIE in North America, Clara in Latin America, etc.

It is expected, however, that outreach activities from the universities will make this framework for development and learning serve as a source of know-how and inspiration for the establishment of sustainable broadband markets serving also other sectors of society than academia.

The proposed capacity building includes three levels:

- **i.** individual learning by associating the framework with relevant academic Master and PhD programmes (CS, EE, IE, etc) already offered at universities in the region that are also connected to the member NRENs. The individual learning part is manifested by diplomas or degrees and could be supported by a scholarship programme and universities outside the region in a start up phase.

- **ii.** Organizational learning in multi-stakeholder partnerships including not only academic institutions but also other interested parties, such as other consumer groups, policy-makers and regulators as well as infrastructure owners and service providers. The organizational learning in these organizations could be stimulated, manifested and acknowledged in certification schemes, awards, etc.

- **iii.** Consortia learning using the neutral academic platform for exploring the roles and relations between different actors of communication markets.

Our earlier experience from using this framework, both in developed and developing regions [CSD], is encouraging. It facilitates dynamic and flexible development processes by focusing on objectives and goals of mutual benefit to all participants, favors holistic approaches and seems to be possible to scale to a global level. We will give some examples of earlier experiences and outline a possible way forward.

## 2. Pilot examples of Development Projects

The project descriptions discussed below are intended as pilot examples to illustrate what a problem-oriented, project-driven framework looks like and how it works. The first group of projects discussed below include already completed projects;

the second is projects under way while the third includes projects in a planning phase. The underlying model has been developed during the last decade by PhD and Master students from both developed and developing countries, especially in Africa, together with researchers, teachers and external stakeholders at the Royal Institute of Technology in Sweden [KTH]. It has proved itself successful in several projects in developing regions .

The Ubuntunet Alliance is interested in catalyzing the adaptation and implementation of the model in Africa. KTH is interested in supporting this by working with universities in the region as well as in the developed world to implement the model locally. Cooperation to this end is already in progress with UEM in Mozambique and DIT in Tanzania.

### **2.1. Access networks and Internet Exchanges**

The first African projects according to this model was conducted in cooperation between UEM and KTH in 2002 and included the extension of the UEM campus network to the student dormitories and the establishment of an Internet Exchange Point in Mozambique, MozIX, at which all Mozambican Internet Service providers are now interconnected to exchange local traffic. The Internet Exchange Point has improved the performance for local applications drastically and at the same time eased the load on the congested international links. Both access networks and Internet Exchange points have later been established in several other African countries according to the same model and involving students from local universities now responsible for the management of the installations. A recent example is the fiber based campus network in Malawi and the Malawi IX, both planned and deployed according to the same model in 2005-2006. Detailed information about these projects is available at <http://csd.ssvl.kth.se/>

### **2.2. Rural Access to ICT**

The Tanzania ICT for Rural Development Programme (ICT4RD) is a broad multi-stakeholder partnership programme involving both public and private sector. The program is managed by COSTECH and Dar es Salaam Institute of Technology in Tanzania and KTH in Sweden. The programme is currently supported by Sida.

The development goal is to design and validate a national programme for the establishment of sustainable broadband markets in rural Tanzania.

There is synergy both on a national level with the emerging NREN-programme and on a regional level with the Ubuntunet Alliance.

Two first pilots being deployed both involve a 1 Gbps Ethernet over optical fiber, creating a self-sufficient broadband island with narrow-band connections to each other and to the Internet. The primary focus is basic public sector services, such as telemedicine between rural primary health centers and district hospitals, schools, local government administration, including support to small businesses and local entrepreneurs.

- The Serengeti Pilot is using a Tanesco fiber deployed in the rural electrification programme Bunda-Nata-Mugumu in the Mara region - The Wami pilot using fiber deployed for metering purposes along a water supply pipeline in the Coast region and eventually connecting more than 300.00 households and small businesses, mainly agricultural.

All details about the programme is available at <http://www.tslab.ssvl.kth.se/themes/ict4d/tz/>

### **2.3. Academic Backbones**

In all countries of the region, there is an emerging optical fiber infrastructure. We have chosen here to take the Malawi Research and Education Network (MAREN) as an example. In the MAREN framework, a multi-Stakeholder partnership is being established involving all Malawian universities and research institutes, the regulator (MACRA), infrastructure owners and telecom operators (ESCOM, MTL, TAIDE), Internet Service providers and their association (MISPA) managing the Malawi IX (MIX).

In return for participation in the capacity-building activities of the proposed three year development project, ESCOM and MTL have committed to providing the infrastructure necessary to establish a fiber backbone connecting the university campuses.

A first phase is planned to start in January 2007 with the objective to establish a Gbps link between the campus networks in Blantyre at College of Medicine and in Lilongwe at the Kamuzu College of Nursing.

A detailed plan, similar to a project conducted in 2004 connecting a university in Sweden and one in Latvia ([www.balticopen.net](http://www.balticopen.net)), is being designed with a budget target below 150 MUSD,

## **3. Capacity Building**

We have above discussed research and development activities facilitating a wider use of the emerging African communication infrastructure. We will in this section discuss how these activities can be executed and at the same time used to drive the

necessary capacity building of human resources in a problem-oriented, project driven way.

The demand for capacity building involves three levels, the individual level in degree programs, the organizational level which could be stimulated by certification procedures and awards, and the consortia level that could be documented in policies, regulations and agreements, when appropriate.

### **3.1 Individual learning in Degree programs**

The appropriate academic levels to discuss include the Master level and the PhD level. There are currently very few, if any, such programs in the networking area at African universities. There is a rapidly growing demand for network designers and administrators as well as academic staff capable of sustaining advanced research and education in the networking area.

The development of NRENs and the Ubutunet backbone provides a unique opportunity to organize this capacity building in a problem-oriented, project-driven way also exploiting innovative pedagogical methods such as peer and vicarious learning. The model means that the bulk of the development work is performed by senior level master students with complementing backgrounds working in teams coached by PhD-students and supervised by professors, external experts, project owners and other stakeholders.

There are successful examples of academic programs organized in this way in different scientific areas around the world. In the networking area, one such example is the Communication Systems Design framework developed at KTH and offered as part of the Master level curricula in Computer Science, Electrical Engineering, Industrial Engineering, Media technology, etc.

On the PhD level, students are involved in the planning and implementation of the Master level projects as coaches or specialists, and as liaison to the stakeholders in the multi-stakeholder partnerships.

To prevent brain-drain and stimulate institutional relations, both the Master-level and PhD-level programmes are following a sandwich model in which the students always spend at least 50% of their time at their home institution.

### **3.2 Organizational learning**

The transformation of the communication market requires many organizations to acquire new skills, hire new categories of staff members and establish activities in new sectors. The organizational learning

aspect is intended to support the development of quality assurance procedures in the development process, in terms of awards, certificates, etc. These procedures could be organized by industrial associations in different sectors, consumer organizations, public agencies, etc.

### **3.3 Consortia learning**

This component refers to the exploration of the interfaces and relations of different sorts between different actors on the market, such as rules and regulations for fair competition, transparent cooperation, quality assurance, etc. The consortia could consist of broad spectrum multi-stakeholder partnerships, associations of homogeneous groups such as producers and service providers, consumers, policy-makers and regulators, etc.

## **4. PhD-program**

The authors of this proposal have been working on different research projects which are closely related to the ongoing research on service and network infrastructures in the European FP6 and FP7 frameworks. Some examples of research projects that we believe can serve as drivers of a PhD program associated with the development activities are presented below.

### **4.1 Mapping the African Internet.**

The decentralized nature of the Internet, the complexity and diversity of its infrastructures, owners and operators as well as commercial incentives for providers to obscure their network infrastructures, have made comprehensive knowledge of Internet connectivity increasingly difficult.

There is therefore a need to determine, accurately and anonymously, where Internet resources are logically and geographically located in the African Internet. The resources include autonomous systems (ASs), peering relationships, Internet service provider (ISP) points of presence (POPs), routers and links, as well as the capacity and bandwidth of these resources.

This information will provide insights into many aspects of Internet operation and performance, including network ownership, bandwidth and resource provisioning, connectivity to neighboring networks, intra- and inter-domain routing policies, client populations, workloads, loss patterns, congestion, network failures and vulnerability to attack on high-degree hubs. The information can also provide insight into future network behavior,

suggest strategies for network provisioning, traffic engineering and operation of the future network.

Such a project would facilitate the identification and understanding of the economic and technical factors that drive and constrain the deployment and growth of the African Internet. The project would attempt to predict future traffic growth as driven by technical developments and customer demand, determine where and how much Internet resources should be provisioned to cost-effectively satisfy the growing demand, and develop a mathematical model of the performance of the African Internet under various traffic and topology scenarios.

#### ***4.2 Secure and manageable service platforms***

To empower users and service providers to take advantage of the merging African communication infrastructure, it is essential to improve the security mechanisms and management procedures. Service provision and development of new services and applications.

Research in this area is intensive around the world and the African networking community needs to connect to these activities.

#### ***4.3 Next generation IP network Management.***

The Internet backbone is evolving from a wide spectrum of more or less complex protocol stacks to thinner stacks with the Internet Protocol (IP) running directly on top of optical communication links and cross-connects. This development is expected to increase the performance and lower the cost of the future networks. The legacy technologies require complex and time-consuming manual network planning and configuration by a group of "layer experts" to operate and maintain a hybrid data/optical network, while the emerging protocols promise automated operation and management allowing the different layers to be managed by a single network operator.

The bottleneck in the IP – Optical integration is a matter of technical immaturity. The research issues include (1) identification of quality of service requirements of the different network layer interfaces (2) mapping of these requirements into routing mechanisms and network control strategies and (3) the deployment of these mechanisms and strategies within and beyond an Internet domain's boundaries to maximize the engineering and economic efficiency.

#### ***4.4 Inter-carrier Bandwidth on Demand.***

Bandwidth trading appeared in the late 1990's to provide electronic marketplaces where buyers and

sellers could trade bandwidth anonymously. The concept promised more bandwidth becoming available at lower cost, but was seriously affected by the economic downturn in 2001. There was also a lack of appropriate business models and some technical limitations

The emerging protocols make the status of the network resources visible to a common network control, at least within an administrative domain belonging to one operator. However, achieving bandwidth on demand beyond a domain boundary is still an unsolved problem. This project revisits the problem of Bandwidth on Demand to propose network management mechanisms to be deployed to achieve successful inter-carrier bandwidth exchanges. Research issues include service level agreement monitoring, inter-carrier service provisioning, bandwidth exchange strategies and inter-carrier charging and billing procedures.

### **5. Master Program in Internetworking**

A possible template for a Master level program in Internetworking is the program offered by KTH, taught in English with international recruitment ([www.it.kth.se/intms](http://www.it.kth.se/intms)), from which some of the authors have a direct experience. There are currently 4 students from the region in the program. It is a two year program with one year of traditional courses, and one year of problem-oriented, project driven learning that can be driven by the development program discussed above. Half the second year is organised as teamwork in project teams while the other half is an individual thesis project.

### **6. Professional continuing education**

Another important component in the capacity building program is the continuing education of professional already active in industry, public administration and other sectors of society. Such education can be organised in the multi-stakeholder partnerships involved in the development projects discussed above.

### **7. A distributed organization**

A template for the problem-oriented, project-driven framework should be developed in broad cooperation. It can then be adopted and implemented independently by universities in the region that will give it slightly different profiles depending on local prerequisites and expertise.

Students should be allowed to move between the universities while spending a minimum part of their education in their home institution and environment.

## 8. Recommendations

The authors of this paper are all in a position to contribute to the implementation of the framework for development and capacity building discussed, provided that political and financial support is made available. We also have the human networks required to involve our colleagues at other universities and other countries in the region to join this effort. We ask African leaders to support us in the following ways.

- Startup MSc and PhD level courses in the field of Internetworking, with support from outside the region, according to the model developed at KTH and successfully tested over a considerable period. The model would be to support a regional institute and/or to support efforts at different universities where students enrolling for masters would be allowed to move around universities as well as to take some part of their Masters or PhD at universities outside the region according to sandwich schemes.
- Research and Education institutions should come together and create a national research and education network that should be in turn

connected to the regional network that UbuntuNet Alliance is pursuing. In doing so the universities should thrive to use this as an opportunity to lower the costs to other segments of the society.

- Startup training courses aimed at improving the knowledge on how to regulate the telecommunication market as way to increase the use of IT so that it can be a driving factor for education and economic development.

## 9. Conclusions

The Ubuntunet Alliance and the abundant support it is receiving, provides a golden opportunity to establish networking as a discipline at African universities and have them spearhead the development of a knowledge society in Africa. It is important to seize this opportunity.

## 7. References

[UA] Ubuntunet Alliance Strategic Plan, Zomba, Malawi, October 2006

[OA] Open Access for Africa, UN ICT Task Force, November 2005

[CSD] Communication Systems Design, a framework for problem-oriented, project-driven development and learning (<http://csd.ssvl.kth.se/>)