CREATING THE HUMAN AND INFRASTRUCTURE RESEARCH AND EDUCATION NETWORKS IN AFRICA

F F Tusubira
Ag CEO, UbuntuNet Alliance, 501 Communications House, 1 Colville St, Kampala, Uganda
ceo@ubuntunet.net

"When the webs of a spider combine they can trap a lion" – Ethiopian Proverb

Abstract.

The pioneering activities of the UbuntuNet Alliance have stimulated unprecedented growth within the research and education community in Eastern and Southern Africa, starting at the human and institutional level and now moving on to the infrastructure level. The dream of connectivity equity for Africa based researchers has started becoming a reality.

The current state of play of research and education networking within the UbuntuNet Alliance region, capturing challenges as well as strategies, is discussed. Specific focus is given to the Policy and Implementation Master Plan.

Key words: Research Networks; Regional RENs in Africa; UbuntuNet

1. INTRODUCTION

We posit as the UbuntuNet Alliance that digital isolation is a major contributing factor to the limited intellectual output from the African continent. This isolation is largely due to the excessively high cost of internet connectivity, with institutions paying typically USD7,000 per full duplex Mbps per month[1], bandwidth that would cost less than USD20 per month in North America and Europe. This reality was the backdrop for the formation of the UbuntuNet Alliance, with the intent of acquiring fibre capacity so that African research and education institutions would achieve not just equity, but equality to the rest of the world in terms of volume and cost of bandwidth.

Since it was first conceived almost four years ago, the Alliance has evolved into a true regional organisation that is stimulating the growth of research and education networking in 22 countries in eastern and southern Africa. The imminent arrival of marine fibre on the East coast of Africa and increasing liberalisation as well as investment in national fibre backbones has created new opportunities for the Alliance that, properly exploited, will see Sub-Saharan Africa's digital isolation removed for the first time, enabling the strengthening of the human research and education networks – our key objective in working to eliminate digital isolation.

This paper gives a brief history of the Alliance. It then discusses the current state of research and education networking in Eastern and Southern Africa, analysing both opportunities and challenges. The UbuntuNet Policy and Master Plan, developed to define a systematic path for addressing the digital isolation is also discussed.

2. ORIGINS OF THE ALLIANCE

Three factors can be said to have led to the opportunistic creation of the UbuntuNet Alliance. First were the studies conducted during the early to mid-2000s, like the SARUA Fibre Study [1], that started bringing to light the substantial reservoir of unutilised optical fibre capacity in Africa, owned especially by power and railway companies. Second was a new wave of liberalisation as monopoly and other limited competition provisions stipulated during the first wave of liberalisation in the late nineties expired, creating opportunity for such fibre to come on the market. Third, and especially significant, were the plans for the first east coast submarine cable, known as the East African Submarine System, or EASSy. Driven by internal need, availability of the

[1] VSAT providers charge for half-duplex bandwidth. The current lowest cost is about $1,800 for a half-duplex Mbps per month or USD3,600 full duplex. Most institutions pay above USD3,000 per half duplex Mbps per month, or USD6,000 for full duplex).

opportunities cited, and catalysed by external suggestions[2], embryonic and developed NRENs in five countries came together to initiate the development of an African regional REN[3]. At the Internet2 2005 Fall Meeting in Philadelphia during an informal chat among African pioneers in the lobby, Duncan Martin of TENET mooted the name "UbuntuNet" for the regional REN. The name eclipsed all earlier attempts at baptism. The UbuntuNet Alliance was registered in March 2006.

Membership has doubled since that time as new NRENs have been formed and become members of the Alliance. Current membership includes Eb@le (Democratic Republic of Congo), KENET (Kenya), MAREN (Malawi), MoRENet (Mozambique), RENU (Uganda), RwEdNet (Rwanda), SUIN (Sudan), TENET (South Africa), TERNET (Tanzania) and ZAMREN (Zambia). The Alliance is also in active contact with the rest of the countries in the region to support them in establishing NRENs and becoming members of the Alliance. The map in Figure 1 shows the current membership.

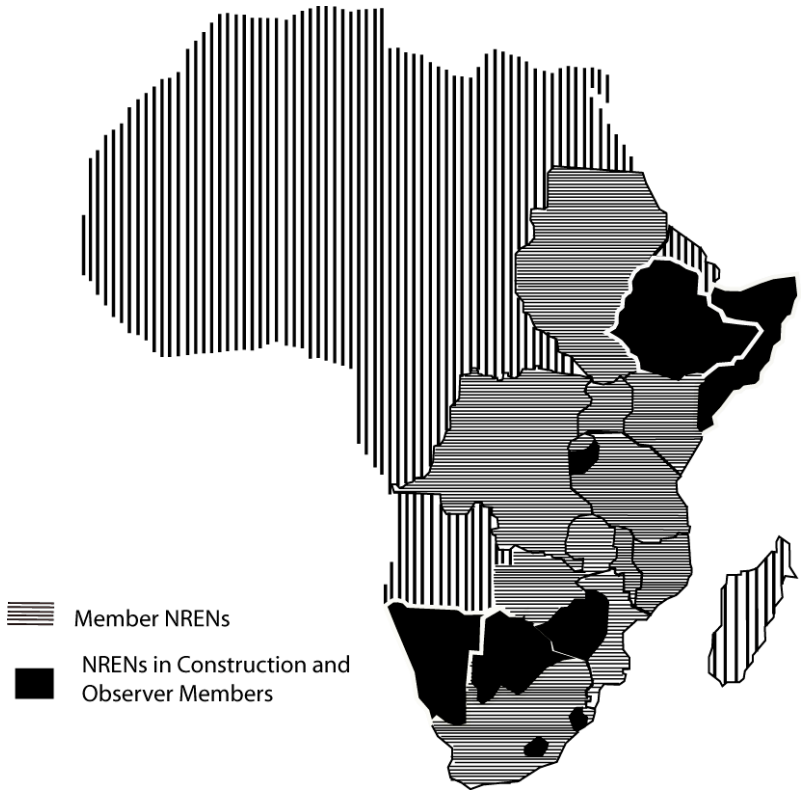

Figure 1: UbuntuNet Alliance Membership

3. CURRENT STATE OF REN ACTIVITY: OPPORTUNITIES AND CHALLENGES

NRENs in the membership region are at various stages of development, with TENET of South Africa being the most advanced. The only other operational NRENs are KENET of Kenya and SUIN of Sudan. The rest of the member NRENs have been set up as formal organisations at the human level, some of them at fairly advanced stages of acquiring and operationalising data network infrastructure (MAREN, RwEdNet, MoRENet, RENU) and others just starting off (Eb@le, TERNET, ZAMREN).

[2] Prof Bjorn Perhson of KTH and Steve Song, then of Connectivity Africa, were some of the key external parties that encouraged the setting up of a formal organisation.

[3] The pioneers were Victor Kyalo of KENET, Kenya; Margaret Ngwira of MAREN, Malawi; Duncan Martin of TENET, South Africa; Americo Muchanga of MoRENet, Mozambique; Albert Nsengiyumva of RwEdNet, Rwanda. The author was part of the initial discussions, but could not participate formally: there was no formal NREN in Uganda at the time.

Regardless of the stage of development, there is a multiplicity of opportunities as well as challenges to be addressed in order to increase research and education networking activities in Africa. These are discussed in some detail below.

3.1 Opportunities

3.1.1 A growing awareness among African countries of the importance of increased investment in higher education as a key pillar for national development.

Various studies have demonstrated the direct link between investment in higher education and national development. The World Bank is particularly working to disseminate this information among developing countries, a few of which are responding through increased direct investment or the provision of student loans. The need for skills is also linked to the efforts by many countries to attract foreign direct investment in competition with other investment, both African and non-African. Better resourced universities are able to provide more realistic funding for information and communication technology, creating environments in which national, regional, and international research and education linkages grow and thrive.

3.1.2 Increasing liberalisation of the telecommunications sector

As will be discussed later, policy and regulation remain a major challenge. The general trend has nevertheless been an increasing relaxation of regulation that has enabled entities that have fibre capacity to put it on the market [2]. For a long time power and railway companies particularly have held fibre capacity as part of their signalling and control systems, and are now bringing this hitherto idle fibre on the market, reducing local access costs. Figure 2 illustrates, as an example, the existing and planned fibre of ZESCO, the Zambia power company. This kind of situation obtains in all countries in the membership region that have well-developed power and railway sectors.

Sector liberalisation has also given opportunity to NRENs to set up, own and operate private networks, including international gateways. In Uganda, for example, any private entity can set up and operate its own network and set up a VSAT, subject only to the payment of spectrum fees. KENET, MAREN and TENET all hold telecommunications licenses from their national regulators that permit them to build and operate their own networks and provide services to their member institutions.

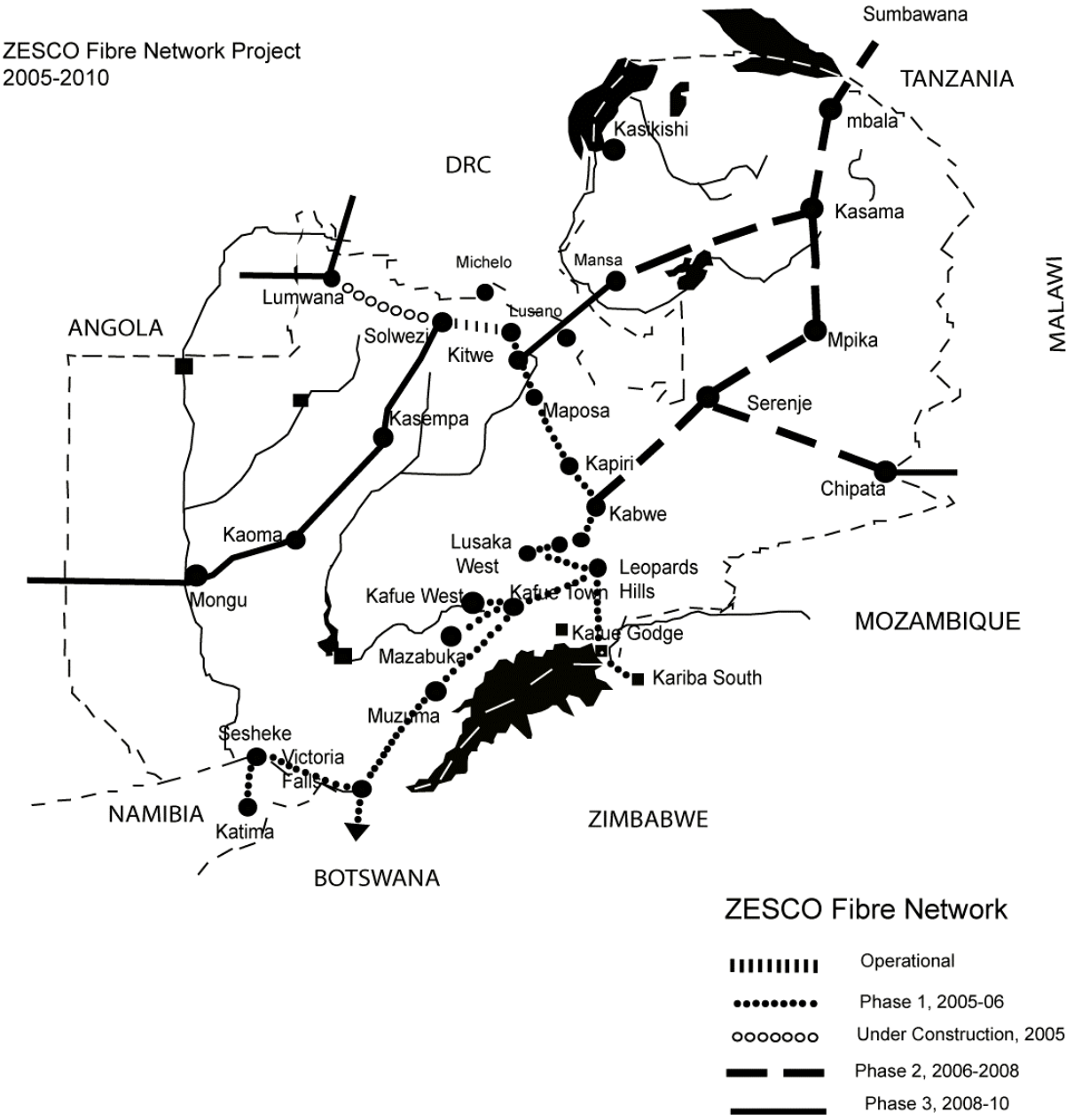

Figure 2: Existing and planned fibre of the Zambian power company, ZESCO.

3.1.3 Investment into national fibre backbones

The first wave of liberalisation in the nineties saw most governments pull entirely out of the development of telecommunications infrastructure. It was realised after some years that while there was heavy investment in mobile telephony (motivated by demonstrated rapid returns on investment), there was very limited investment in high capacity data backbones, the workhorses of the internet. Plans for e-enabled services (education, health, commerce, governance, etc) on which many governments had embarked could not move ahead. Over the last three years, many governments (for example Uganda, Kenya, Rwanda, Tanzania) have moved to establish extensive national data backbones. Access for the education and research sector has been made a priority in most cases. Other countries like Ethiopia moved even earlier into the implementation of national backbones as public projects. All these countries have received support from bilateral and/or multi-lateral development agencies: data backbones are now considered as key development infrastructure.

Figure 3 is an illustrative example of the Uganda national data backbone [2] of which Phase 1 has been completed. The Research and Education Network of Uganda (RENU) has been promised free dark fibre capacity on this network.

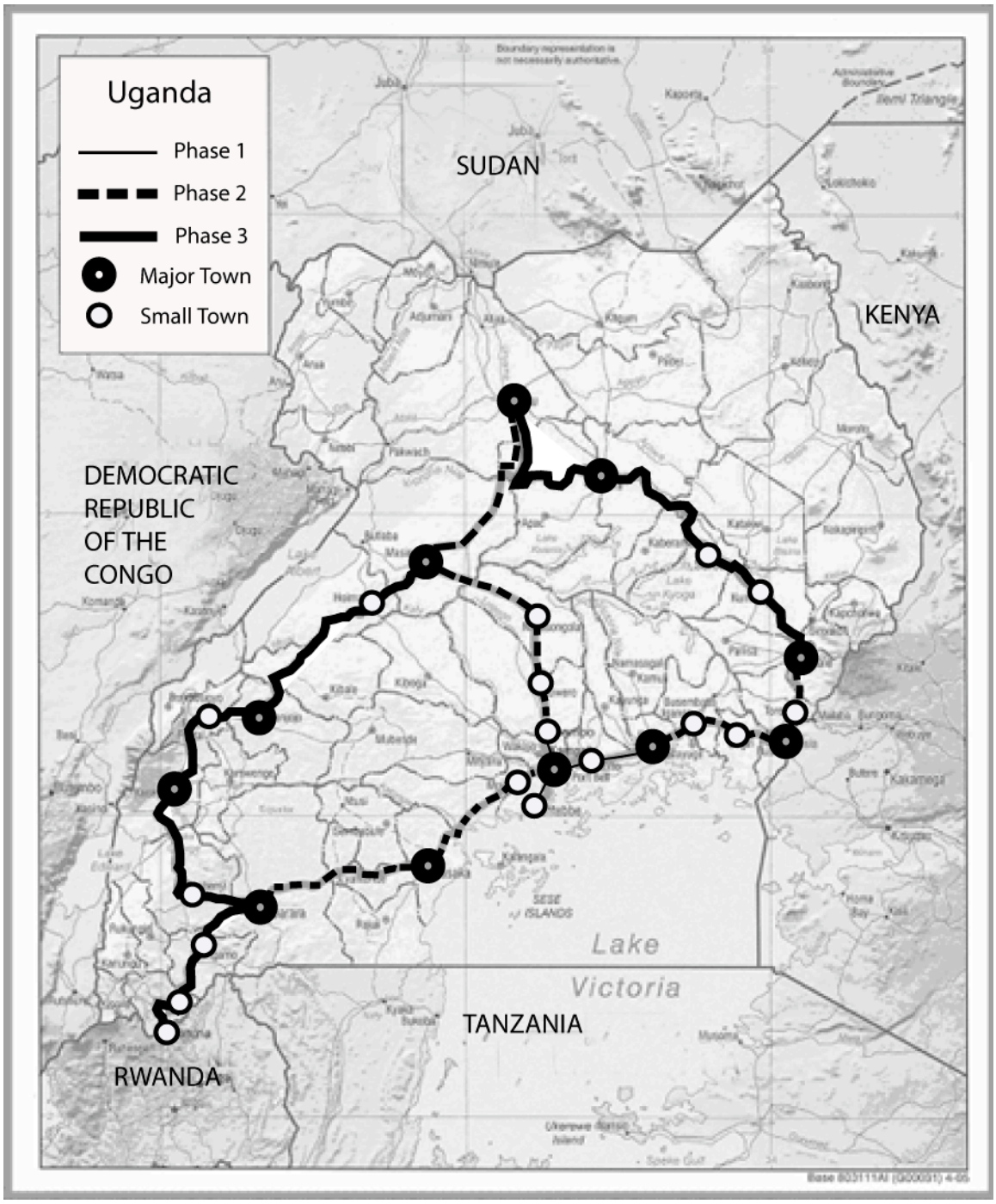

Figure 3: The Uganda National Fibre Backbone

3.1.4 Increasing research linkages between African and non-African universities

Nothing demonstrates the insufficiency of bandwidth to external institutions more than a research linkage requiring the exchange of large files. This is especially true of the increasing linkages relating to medicine, physics, climatology, and other data-intensive areas of research. The external institutions have become key advocates for their governments and foundations to support improved research and education networking connectivity to and within Africa.

A specific current example is four leading schools of medicine in the USA (John Hopkins, University of Washington, University of California San Francisco, University of Pennsylvania) establishing linkages with four leading schools of medicine in Africa (Makerere University, Muhimbili University of Health and Allied Sciences, University of Botswana, University of Nairobi) in a programme to train leaders in global health. These have identified sufficiency of connectivity as a key challenge to be addressed from the outset.

3.1.5 The number of high capacity marine optical fibres planned to land on the African coast starting 2009.

For the last fifteen years, there has always been one major plan or another to bring increased connectivity to Africa. Most of these failed to deliver results, to the extent that most people both within and outside Africa remain sceptical about the success of current efforts. It is the case of the folk story character, a boy who created disbelief by shouting "Lion, Lion!" once to often for fun, and got eaten when a real lion turned up. Figure 4 shows planned marine fibres to Africa [3]. The relative thicknesses of the lines show the relative capacity.

SEACOM is already being laid with a planned operational date of June 2009. Similarly, EASSy has reached financial closure with an operational date of June 2010, and TEAMS, running from Mombasa to Fujairah, is expected to be operational around the same time. During early April 2009, WACS signed a turnkey contract with Alcatel-Lucent for laying of their cable with a planned operational date of 2011. WACS will connect South Africa to the UK with landings in Namibia, Angola, the Democratic Republic of Congo, the Republic of Congo, Cameroon, Nigeria, Togo, Ghana, Côte d'Ivoire, Cape Verde, the Canary Islands, and Portugal. SEACOM, EASSy, TEAMS and WACS will deliver capacities of 1.28Tbps, 640Gbps, 40Gbps, and 3.84Tbps respectively. For the first time, there will be sufficient bandwidth for users, including NRENs, available in a competitive environment, and creating the opportunity for access equality.

3.1.6 The African Pioneers

One of the greatest opportunities for research and education networking in Africa is for the pioneering spirit of determined and committed individuals who are used to creating success within and despite very challenging environments. Some were early adapters to the use and opportunities of the internet, when they used to wait for a North-South orbiting satellite to get a window of access. They have worked on the development of campus networks, national networks, and now the regional network. Such individuals fill the gap between what is possible and what appears impossible: they are critical in any pioneering environment. It is the people network created by these that drives the success of the infrastructure network and enables the applications – through other people networks – to come on board.

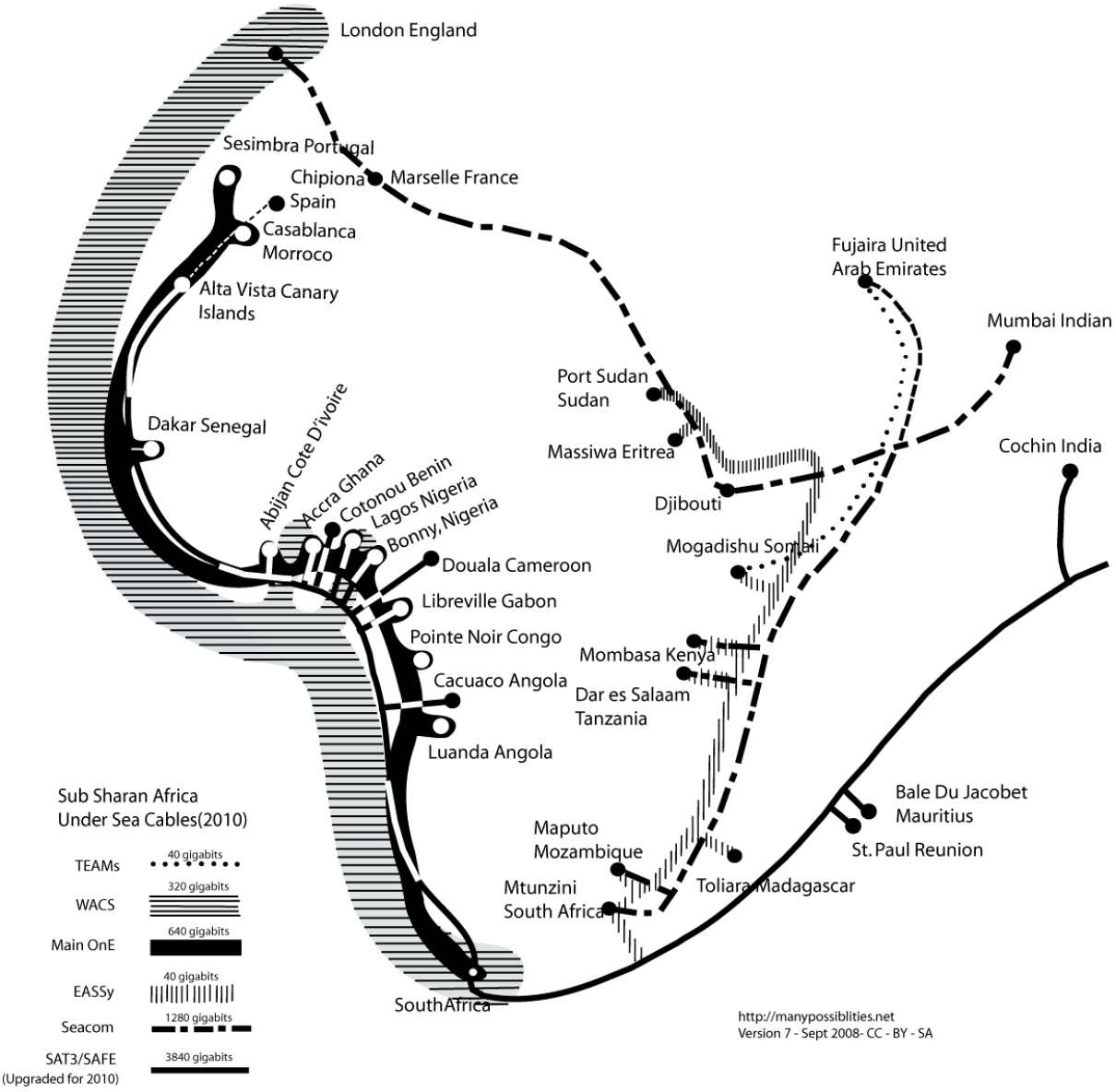

Figure 4: Planned marine fibre to Africa

3.2 Challenges

3.2.1 Shortage of skilled human resource [4]

One of the biggest challenges faced by African institutions and NRENs is the dearth of people who are technically competent to design, operate, and maintain advanced data communication networks. The scarcity is compounded by competition with a rapidly growing private sector able to offer much better terms of employment. The shortage is largely due to curricula in training institutions that supply human resource not matched to needs, taught by lecturers who do not yet understand the real needs of the sector. The Alliance is moving to address this through guidance to institutions about curricula, sharing expertise among NRENs, and creating opportunities for attachments and secondments. Institutions have also been encouraged to fully exploit the unlimited number of innovative bright students who want to learn, to experiment, and push out technology frontiers: there will always be a ready supply of these in universities.

3.2.2 Limited understanding of the multiple roles of research and education networks.

A successful NREN has got to achieve a fine balance between providing and assuring availability of sufficient and affordable connectivity – the entry point for African NRENs; enabling and promoting content networks; and

researching into advanced infrastructure. It must also understand the distinction between providing services for a member group and competing with the private sector. All this comes with experience and understanding best practices: the overwhelming majority of African NRENs are very young and do not yet have the necessary exposure. It is inevitable that fingers will be occasionally burnt. The Alliance has moved to address this challenge through the dissemination of good practice and annual conferences that are really learning events.

3.2.3 Disabling Policy and regulatory environments

As part of the Master Plan and Strategy development process, the Alliance carried out a situational survey of the telecommunications sector policy and regulatory environments covering 22 countries in the Alliance membership region, with specific focus on impact on research and education networking activities [5]. The following were found to be the key environmental barriers to access to broadband communication:

- Slow reforms in the communication sector
- Inadequate access to backbone infrastructure at affordable prices
- Inadequate policies and regulation with regards to ownership and access to essential infrastructure by universities and research institutions

Slow sector reform
Policies and regulation that govern: access to spectrum; ownership of fiber infrastructure such as dark fiber; interconnection; and tariffs, are often unfavourable, and also vary widely. Some governments in the region such as Kenya, South Africa, Tanzania and Uganda have made progress in reforming their telecommunications sector policy, legal and regulatory environments; and have also adopted technology neutral converged regulatory frameworks that promote access to broadband infrastructure. Others like Djibouti, Eritrea, Ethiopia and Swaziland still favour monopoly and restrictive regimes that hamper academic institutions' ownership and operation of broadband fibre and wireless networks.

Access to broadband Infrastructure
A critical aspect of high speed connectivity is ensuring that national and international fiber access is available and affordable. Bandwidth to sub-Saharan Africa still comes through a single submarine cable—the South Atlantic Telephony-3/West African Submarine Cable (SAT-3/WASC, or SAFE) or via satellite connection – inherently poorer in quality and more expensive than optical fiber. The price of SAT3 bandwidth has been kept artificially outrageously high because the cable was, until recent limited relaxation, owned and controlled by a closed consortium of dominant telephone companies and state monopolies.

The existing backbone infrastructure in the UbuntuNet region comprises mainly low capacity, wireless links designed to carry voice traffic. Submarine cable projects should, provided they maintain open access principles, address the international connectivity gaps. Additional backhaul capacity is however required to connect the inland regions and landlocked countries to the landing points: there is a current real likelihood that international fiber with the potential for much cheaper bandwidth will be neutralised to a large extent by the bottlenecks created by the absence of sufficient backhaul and national backbone capacities. Many countries, as discussed, have initiated national backbone projects that will eventually address this gap.

Ownership and access to essential facilities by academic and research institutions
The restriction on academic ownership and operation of network infrastructure is often due to the monopoly of networks by traditional incumbent operators that are regarded as sole owners of the network, including national gateways. In most countries, only the licensed operators and other public utility companies have the Rights of Way, and NRENs would have problems trying to establish their own networks if they so wished. In countries like Eritrea and Ethiopia the restrictions are extreme, with even the use of VSAT and its operation by academic institutions prohibited. In most of the countries NRENs can only purchase fiber capacity from existing licensed providers. This denies them the option to consider ownership models that might be more cost effective or to build networks for special research purposes.

In some countries like Kenya, Malawi, and more recently South Africa, NRENs now have formal licenses to set up and operate national level infrastructure for the benefit of their members.

3.2.4 Seeking individual advantage by member NRENs

It is a natural human trait to seek individual advantage, and group success relies on the ability of the individual to overcome this natural tendency. If there is famine in a village and a supply of food is made available, it

requires enforced discipline for the people to sit and discuss ways of maximising community benefit out of the food: the first reaction is to "grab as much as possible for oneself and immediate family". Africa has been starved of bandwidth for a long time. Suddenly, institutions and NRENs that have been paying USD 7,000 per full duplex Mbps per month see that they can get it at less than 10% of this price, creating a disorderly scramble that disorganises the group interest: with cooperative effort and negotiation, this could go to less than 5% for the group.

3.2.5 Competition from and cherry picking by service providers.

This comes from the expected predatory tendency of the suppliers. In any NREN, there are institutions that are the largest and most affluent. They take the largest chunk of bandwidth. A regional REN like UbuntuNet similarly has member NRENs that are comparatively large consumers of bandwdith. It is very tempting for the supplier, especially if there a positioning among consumers for individual advantage, to enter direct agreement with these at concessionary terms. This weakens the group, making it more easily vulnerable to exploitation. The only solution to this is for the stronger institutions to appreciate that it is actually in their interest to work as part of the group, providing the necessary backbone during negotiations.

3.2.6 Weak Financial Base

This challenge applies to NRENs and the Alliance alike. Where there are no tangible services being offered, it is difficult for member institutions that are themselves cash-strapped to contribute to a start-up organisation. This challenge can only be addressed by moving rapidly, necessarily with development partner support, to offer tangible services that are seen to reduce the costs of members and therefore provide incentive for payment of membership and agency fees. For African NRENs and for UbuntuNet, the only commodity that can achieve this in the short to medium term is much cheaper bandwidth.

4. CONSOLIDATING RESEARCH AND EDUCATION NETWORKING IN AFRICA: CORENA

CORENA is the defining name the Alliance has given to its major undertaking of creating access equality for Africa. The *overall goal* of this project is to enable an environment in which African Education and Research Institutions can exploit their full potential in contributing to national and international human development; and in increasing their countries' contribution to, and share in intellectual property output, through effective national, regional and international collaboration. The project has the *principle objective* of enabling the integration of African universities and research centres into the global research and education community through provision of intra-African connectivity and enabling access to sufficient and affordable international internet bandwidth.

We are working with the Association of African Universities Research and Education Networking Unit, as well as other regional REN organisations in Western and Northern Africa in order to achieve the principle objective.

Our hypothesis is that:

"Improved and affordable connectivity will enable African researchers to produce proportionate intellectual output and generate a proportionate amount of intellectual property goods"

CORENA has defined the framework for the development of our key foundation documents, especially the Strategic Plan, and the Policy and Master Plan[4].

[4] Full documents are available at www.ubuntunet.net

5. PLANNED STRATEGIC OUTCOMES, AND THE POLICY AND MASTER PLAN

5.1 Planned Strategic Outcomes

The Alliance has set the following strategic outcomes for the period 2009 – 2013[6]:

i. NRENs developed in all countries in Eastern and Southern Africa, and their capacity built.
ii. Improved speed and affordability of connectivity for member NRENs. (A target to be achieved within three years is USD200 maximum cost to institutions per Mbps per month)
iii. Assured institutional sustainability of the UbuntuNet Alliance.
iv. Improved national policy and regulatory environments that enable REN activities.
v. Increased interconnections among NRENs within Africa and to the rest of the world.
vi. Increased and effective support for regional content (including research) networks.

This is quite a large bite, considering the size of the region and the current status. The projected budget to achieve all this is USD43million. The Policy and Master Plan, key elements of which are discussed below, has been developed to guide implementation.

5.2 The Policy and Master Plan [6]

5.2.1 Key Policies

UbuntuNet Alliance is a member-driven institution that aims at exploiting aspects where it is beneficial to work together while respecting the independence of its members. It will maintain a lean structure, relying on outsourcing services to members to keep operational overheads low. The Alliance does not simply seek cheap bandwidth: it seeks to implement connectivity among our member NRENs and to the rest of the world with bandwidth, quality, and cost compatible with the rest of the global research and education community. The pricing of services will in all cases be distance-neutral.

The Alliance covers only Eastern and Southern Africa, and therefore recognizes the need to work with other regional RENs in Western and Northern Africa to achieve a truly continental network. While it relies on the support of development partners for the short to medium term, it is committed to the sustainability of all recurrent costs within three to four years: its business strategy and plan capture this.

5.2.2 Infrastructure Vision and Master Plan

Figure 5 shows the regional backbone vision. Realism about the size of the continent and the undertaking required a cluster approach: the Eastern and Southern clusters (Figure 5). Each can develop independently based on a common architecture, later merging with the other into one network.

Five major sub-projects have been defined for the delivery of the infrastructure vision. These are the Virtual REN (VREN); the Regional Backbone; the Africa-Indian Ocean Wave; the Network Operations Centers; and International Connectivity.

The Virtual REN Project
The Alliance defines a "VREN" as a research and education network based on access via VSAT consolidated through the teleport of a single satellite service provider. This project is aimed at connecting NRENs (or their nominated members) that use VSAT for international access to the UbuntuNet Router in London. The project will address, in the short-term, the challenge of establishing connectivity of NRENs to the international research and education community through the UbuntuNet Router in London. It will, in the medium term, continue enabling those NRENs that do not have access to international fiber backbone to get to the London UbuntuNet POP.

The Regional Backbone Project
The regional backbone is aimed at ensuring regional connectivity so that local traffic within the sub-region is kept local; cross-border connections are transparent and cost-neutral to the NREN community; and all landlocked countries have access to the international (i.e, external to Africa) fiber landing points. A key factor

in the implementation of the Regional Backbone is the sector policy and regulatory environments that vary widely from country to country within the region. From the situational analysis conducted, we have noted that the policy and regulatory environments have been becoming increasingly amenable to NREN activity: There is now leeway, in many cases, for regulators to make dispensation to NRENs. While this is not the ideal, it is a positive starting position.

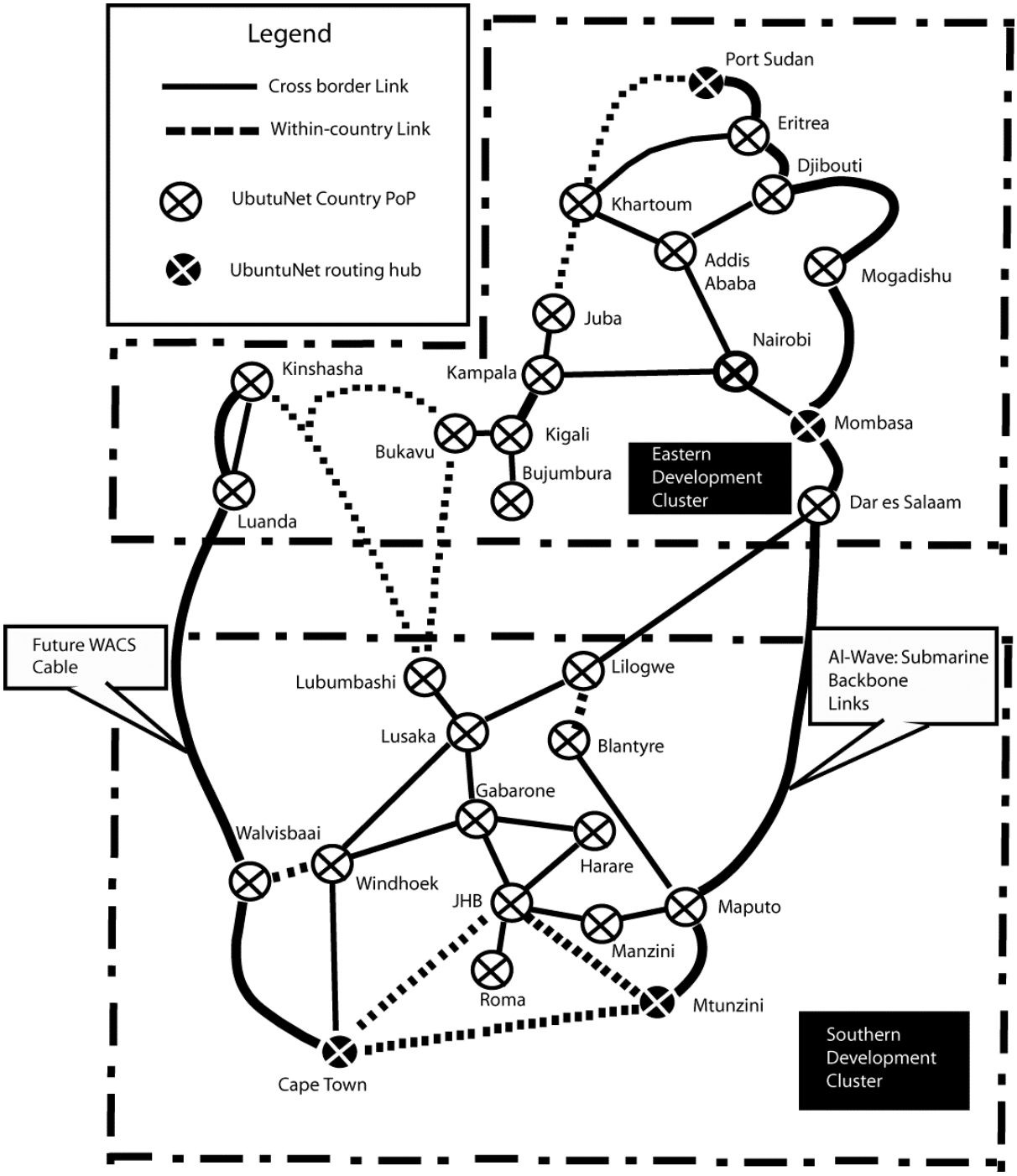

Figure 5: UbuntuNet Alliance Regional Backbone Vision

The need for cross-border links in multiple regulatory environments would call for multiple contracts and also require UbuntuNet to have legal corporate existence in each country. To avoid that, UbuntuNet has adopted a policy of working through NRENs to secure and manage the transit routes.

The Africa-Indian Ocean Wave (AI-Wave) Project
The AI-Wave Project is aimed at implementing a sea-based regional backbone following the Indian Ocean along the African coast. The current regional protocols permit land-locked countries access to the cable landing points. This creates opportunity for making the cable landing stations points of interconnection, enabling routing the regional backbone traffic along an ocean based path without the policy and regulatory challenges of cross-border operations. It is this ocean-based path the Alliance has dubbed the African-Indian Ocean Wave, or AI-Wave. The AI-Wave will be established through 10Gbps circuits connecting Port Sudan, Djibouti, Eritrea landing point, Mogadishu, Mombasa, Dar es Salaam, Maputo, and Mtunzini.

The Network Operations Centers Project
The objective of Network Operations Center (NOC) Project is to ensure that service level agreements are fulfilled through proactive monitoring and resolution of any network glitches that can militate against this. This includes remote layer 3 management and layer 2 monitoring, in each case triggering corrective action through the NOC itself or through NRENs and other outsourced service providers. The NOC will also provide the Help Desk function that may be outsourced. To define the lines of communication, each member NREN will designate a person or persons (if the latter, in hierarchical order) to be the point of contact with the NOC.

The International Connectivity Project
This is aimed at securing connectivity to the international research and education community through fiber at prices comparable to Northern America, Europe, and the Pacific countries. The approach to securing international bandwidth will also be opportunistic as already discussed under the Regional Backbone Project. In addition to this, UbuntuNet will actively market the region as a destination for other regional and international RENs, inviting them to meet UbuntuNet in Africa at the fiber landing points, a change from the current approach that expects African RENs to meet the more established RENs in Europe or the Americas.

6. CONCLUSION

The Alliance acknowledges the size of the undertaking and the associated challenges as well as the risks and limitations, both internal and external. It believes however that the commitment of its Board and Participating NRENs, enabled by the support of its partners, new opportunities, and driven by real need, will inevitably lead to success.

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ceo@ubuntunet.net