Overview of Fibre Infrastructure Opportunities in the UbuntuNet Region[1]

(April 2009)

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[1] This Study was carried out for the UbuntuNet Alliance by Dr Lishan Adam and edited by Eng Dr F F Tusubira during the second half of 2008. It was updated April 2009.

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1. Introduction

High speed connectivity is crucial for universities in the conduct of teaching, learning, research and administration. The overwhelming majority of academic institutions in African countries still rely on satellite connectivity that is very expensive and has constraints of low bandwidth and latency. Coupled with lack of financial resources, this leads to marginalization of Africa based researchers and educators who cannot exploit their full potential within the knowledge society. Access to fibre connectivity is regarded by the UbuntuNet Alliance as the main route out of the current bandwidth challenges.

Successful deployment of optical fibre networks requires investment across the whole supply chain including (i) international connectivity to the rest of the world, (ii) regional or cross-border backhauls that interconnect countries, (iii) national backbone that extend access to major towns, and (iv) last mile connection to the universities. Significant progress, in terms of financing closure and actual implementation, has been made in bringing international submarine fibre connectivity to Africa and building national backbones; but progress in regional and cross-border connectivity remains very slow due to differences in political, regulatory and economic environments among African countries. The establishment of National Research and Education Networks has stimulated interests in last mile connectivity to the universities in Africa in recent years, but the policy and regulatory environments are not clear with regards to university' ownership and operation of fibre links. This paper looks at the overall supply chain of fibre connectivity to the Universities in the UbuntuNet region. Policy issues are addressed in a parallel paper[2].

2. International Submarine Cable Projects

The last five years have seen significant fibre network build out around the world, especially in South and East Asia and Africa. The total investment in sub-Saharan African undersea fibre optic cable over the last decade was around US$1 billion. This was spent for the construction of the SAT3, Atlantis, Falcon and SEA-ME-WE cables. African fibre investment is expected to quadruple in the current decade. Submarine fibre projects with a cost of over US$2.5 billion are currently underway and two-thirds of these are expected to be operational before the well-publicized World Cup to be hosted by South Africa by 2010.

Three major submarine cables are currently being deployed to offer east and southern African countries with much needed cheap connectivity.

- The SEACOM submarine cable due to become operational during the third quarter of 2009 is being built by a consortium of private companies including Herakles, Blackstone, Aga Khan Fund, Venfin, Convergence Partners, Shanduka and the second national operator of South Africa Neotel.

- The East African Marine System (TEAMS) owned by the Government of Kenya, the Kenyan private sector and UAE based mobile operator Etisalat is another cable due to be operational during the second half of 2009.

- The East African Submarine Cable System (EASSy) that is financed by public and private operators from east and southern African countries, the International Finance

[2] UA 201: The Policy and Regulatory Environment vis a vis REN Activities

Corporation, the European Investment Bank, and the African Development Bank among others is expected to be operational in 2010.

- The West African sea board that is being served by the SAT3 cable is also expected to secure a cheaper fibre alternative when the 14,000Km West African Cable System (WACS) becomes operational in 2011. The consortium that is building WACS consists of an equal share split between Telkom, Neotel, MTN, Vodacom, and the South African government's Broadband Infraco.

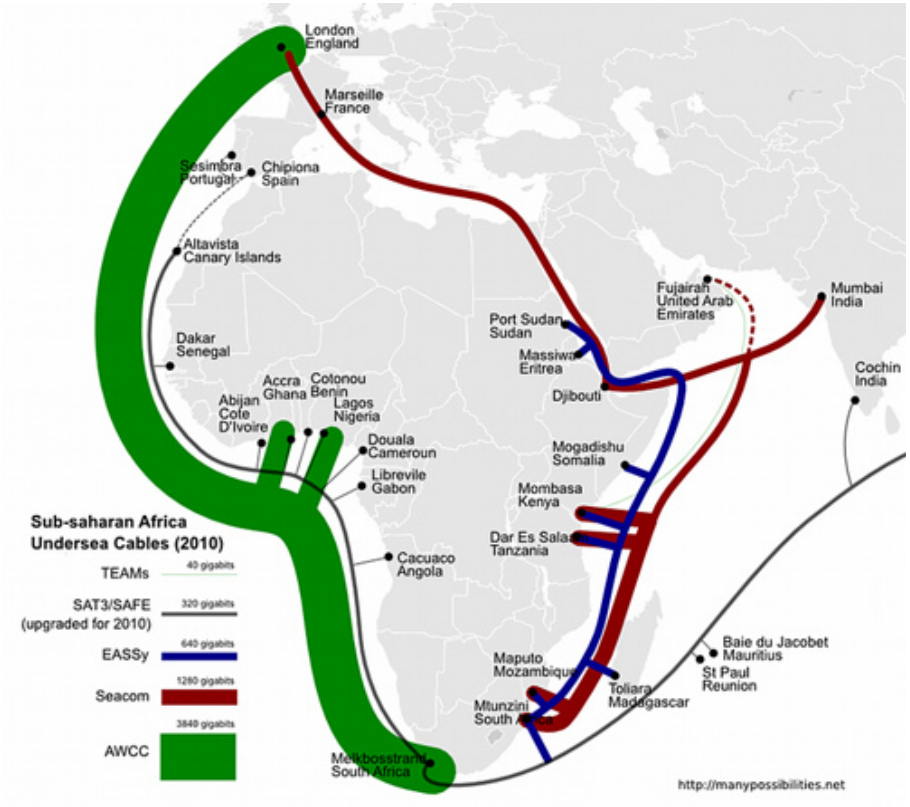
Other projects that are at an advanced stages include Glo-1 for connecting Nigeria to UK by the Nigerian second national operator with a cost of over US$650 million and Main One a cable from Angola to Portugal with a cost of US$300 million. Table 1 Lists major fibre projects expected to be operational by 2012.

Table 1. Major African Submarine Cable Projects

Submarine Cable	**Links/Distance**	**Major Player**	**Estimated cost million US$**	**Operation date**
SEACOM 	East and southern Africa	Herakles, Blackstone; Aga Khan Fund; Venfin; Convergence Partners; Shanduka Neotel	650	Second half of 2009
TEAMS 	Kenya to UAE 120 Gbps	Government of Kenya (40%), Etisalat (UAE) (15%)	82-110	2009
EASSy 	East and southern Africa	IFC, EIB, Kfw, AfDB, operators	265-330	2010
WACS 	West Africa, UK, 14,000 Kms, 320 Mbps	Telkom, Neotel, MTN, Vodacom, Infraco.	510	2011
Glo-1	Nigeria- UK	Glo – second national operator	560	2012
Main One 	Angola- Portugal	Main Street technologies	300	2012

The completion of the three major submarine cables in time for the 2010 world cup will have a significant impact on access bandwidth to the majority of African countries. Figure 1 shows the African international connectivity bandwidth map[3].

[3] See http://manypossibilities.net/ by Steve Song



Source: Steve Song

Figure 1. International Bandwidth by 2011

The launch of international submarine projects has had an important impact in terms of awareness and preparedness of African countries in the area of policy and development of national backbones. The open access debate that followed the EASSy proposal was instrumental in prompting public and private partnership and business models that bring traditional utility companies including gas, power, railway and telecoms to collaborate in building national backbone networks.

3. Regional Backhaul Links

The absence of regional connectivity, in particular to link landlocked countries, and cross-border backhaul connections between neighbouring nations is the key fibre access gap in Africa. The International Telecommunications Union's study in 2007 showed that there is a need for some 66,000 kms of fibre links to bring about connectivity among countries in eastern, southern, central, western and northern African nations. The estimated cost to achieve this was, at that time, was about USD1.2 billion. Table 2 shows that southern and western Africa require a significant mount of regional fibre building in order to interconnect countries. However, some countries (in southern Africa) like Angola, Botswana, Mozambique and Namibia have already built a significant amount of fibre to their borders, making cross-border links much easier and shorter.

Table **2**. Regional Connectivity

Regional links	Central Africa	Eastern Africa	Northern Africa	Southern Africa	Western Africa	TOTAL
Planned	4,406	4,367	3,277	14,757	14,285	**41,092**
Proposed	4,390	1,919	3,889	9,478	5,329	**24,915**
Total	8'796	6'286	7'166	24'235	19'524	**66,007**
Cost $ mil	**220**	**157**	**210**	**510**	**488**	**1585**

Source: International Telecommunications Union (Cost estimates by Dr Lishan Adam)

Various feasibility studies are underway to establish the actual link routes and to identify the amount of resources required to connect countries using various options such as building on infrastructure of the utility companies and mobile operators. It is evident from the Table 3 that despite the critical importance of regional connectivity for trade and regional integration, there has been limited progress in interconnecting among African countries. A considerable amount of work is also required on the legal and regulatory front in particular with regards to cross-border interconnection tariffs.

Table 3. Financing the Regional Backhaul Connectivity in Africa

Projects/regions	**Links**	**Route in km**	**Players**	**Progress**
East African Regional backhaul network	Burundi, Kenya, Rwanda, Tanzania and Uganda and links to Djibouti, Eritrea, Ethiopia and Sudan	4367	World Bank - Regional Communications Infrastructure Programme	Feasibility study addressing missing links financed by the World Bank and the African Development Bank
Southern African regional backhaul network	Backhaul links interconnecting SADC countries	14,757	World Bank - Regional Communications Infrastructure Programme	Feasibility study of the SATA backhaul link financed by the African Development Bank
Central African regional backhaul network	Links between Libreville-Franceville-Lekoni-Oyo-Brazzaville and a Cameroon-Chad-Central African Republic to connect the countries with link the SAT-3 landing station in Douala	4406	No significant players yet	Feasibility study for central African fiber connectivity underway financed by the World Bank
West Africa regional backhaul network	Linking all ECOWAS countries with each other	14,285	No significant players yet	ECOWAS Wide Area Network feasibility study financed by the World Bank and the African Development Bank
Northern – Western Africa	Algiers-Zinder-Abuja trans-Sahara link which has potential to link north Africa with west Africa	3277	No significant players yet	No feasibility study yet

Source: International Telecommunications Union; World Bank; Dr Lishan Adam

There are also efforts by the World Bank to interconnect the Indian Ocean island countries including Madagascar, Reunion, Mauritius, Comoros, Seychelles and Mayotte.

4. National Backbones

The absence of national backbone networks is another obstacle to the widespread use of advanced communication services in the universities. The lack of national backbone infrastructure makes it costly and commercially unviable to provide communication services beyond the main urban centres.

However, there are encouraging activities throughout Africa in recent years with regards to the development of national backbones. A number of countries have developed strategies for building their national backbone and the trend is continuing in other countries. Table 4. shows some of the recent projects and key players in the UbuntuNet region.

Table 4. Recent National Backbone Initiatives in the UbuntuNet Region

Country	Project	Estimated cost	Study Sponsor	Funding
Burundi	National backbone	US$7 million	World Bank	US$7 million from World Bank and operators
DRC	National Backbone	US$233 million	IDRC	US$31 million from Chinese EXIM Bank
Rwanda	National backbone study	US$80 million	World Bank, Government	US$24 million World Bank
Tanzania	National backbone	US$170 million	ZTE, Government	ZTE- Vendor financing
Uganda	e-government backbone	US$160 million	Ministry of ICT/Huawei	Huawei – Vendor financing

National backbones are also being built gradually by operators in other countries: Angola, Botswana, Ethiopia, Kenya, Lesotho, Madagascar, Mozambique, South Africa, Sudan, Zambia and Zimbabwe are among the countries where operator build out activities are taking place earnestly. There is consequently significant progress with regards to availability of fibre networks at national level within the UbuntuNet region.

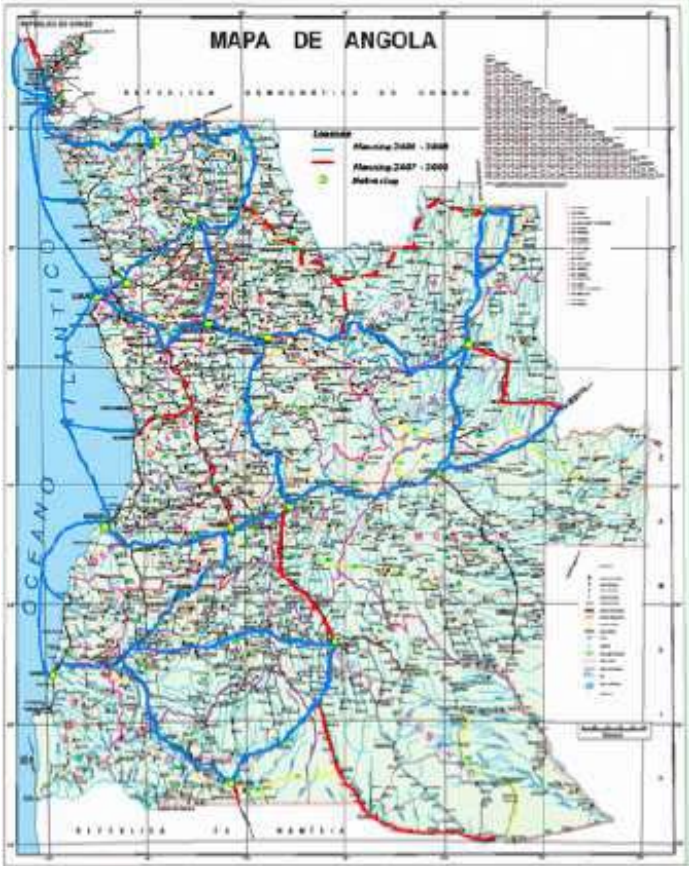
5. Fibre Link Opportunities to the Universities and Research Institutions

5.1. Angola

Angola has been building its national fibre infrastructure through the incumbent operator's project entitled ADONES (Angola Domestic Network System). In 2007, the Angola Telecom allocated US$200-million to establish a national backbone in collaboration with

Siemens. The partnership aims at creating a fibre network that connects all 18 provincial capitals, using a series of intersecting circles that allow for redundancy. A key route of ADONES was along the coast of the country with eight landing points.

Alcatel Shanghai Bell has been responsible for laying the first piece of fibre in the national plan. The fibre goes from the southern coastal town of Namibe, due east to Lubango, before turning south to Ondive, a short distance from Oshikango on the Angolan- Namibian border. In addition Angolan Telecom has a US$300 million project to roll out fibre in collaboration with a Chinese company ZTE. Figure 2 shows the Angola fibre map. The connection of provincial capitals has a significant implication to major universities in Angola and access to sub-marine cable by the Universities in Botswana, Namibia and Democratic Republic of Congo.



Source: APC Fibre Study, Angola

Figure 2. Fibre Map of Angola

5.2. Burundi

Burundi has initiated a feasibility study of a national fibre backbone that links to EASSy, TEAMS and SEACOM through neighbouring countries in collaboration with the World Bank. The aim of the Burundi Backbone (BB) is to promote public and private partnerships in order to leverage the capacities of mobile and fixed line operators and connect to submarine cable via neighbouring countries in east Africa, in particular through Rwanda and Tanzania. Burundi has also received support from the World Bank through a Regional Communications

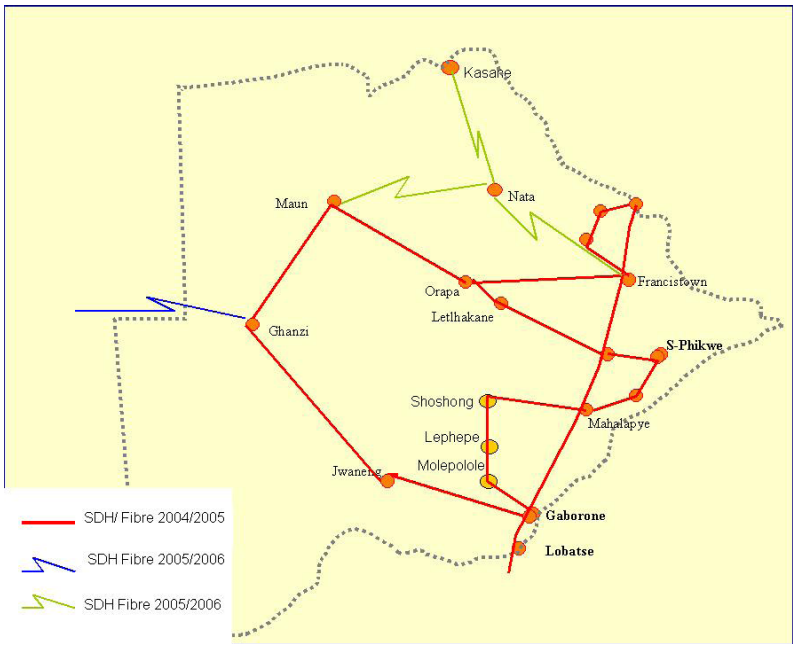
Infrastructure Programme (RCIP) to stimulate access to academic institutions. Figure 3 shows the proposed route of the national fibre backbone in Burundi.

Figure 3: Proposed fibre route for Burundi

5.3. Botswana

Botswana has a well developed national backbone with fibre network available in the more densely populated Eastern part of the country between the major towns of Francistown and Gaborone. Botswana rolled out a 2000km trans-Kalahari fibre network at the end of 2008, paving the way for the country to interconnect major towns and promote access to the upcoming East Africa Submarine Cable System and West Africa Cable System.

The trans-Kalahari has three fibre segments (Figure 4). The first segment connects to Jwaneng, via Ghanzi to Mamuno and then onward to Namibia. The second segment links Ghanzi to Maun and Orapa while the third leg runs from Francistown through Nata, Kasane and onward to Zambian and Namibian border. The completion of the trans-Kalahari network and EASSy and WACS will provide a significant boost to the academic research institutions throughout the country. Botswana is currently developing a national broadband strategy to facilitate effective use of its national backbone network when the international links are available.



Source: National ICT Policy of Botswana

Figure 4. Trans-Kalahari Fibre Network Map

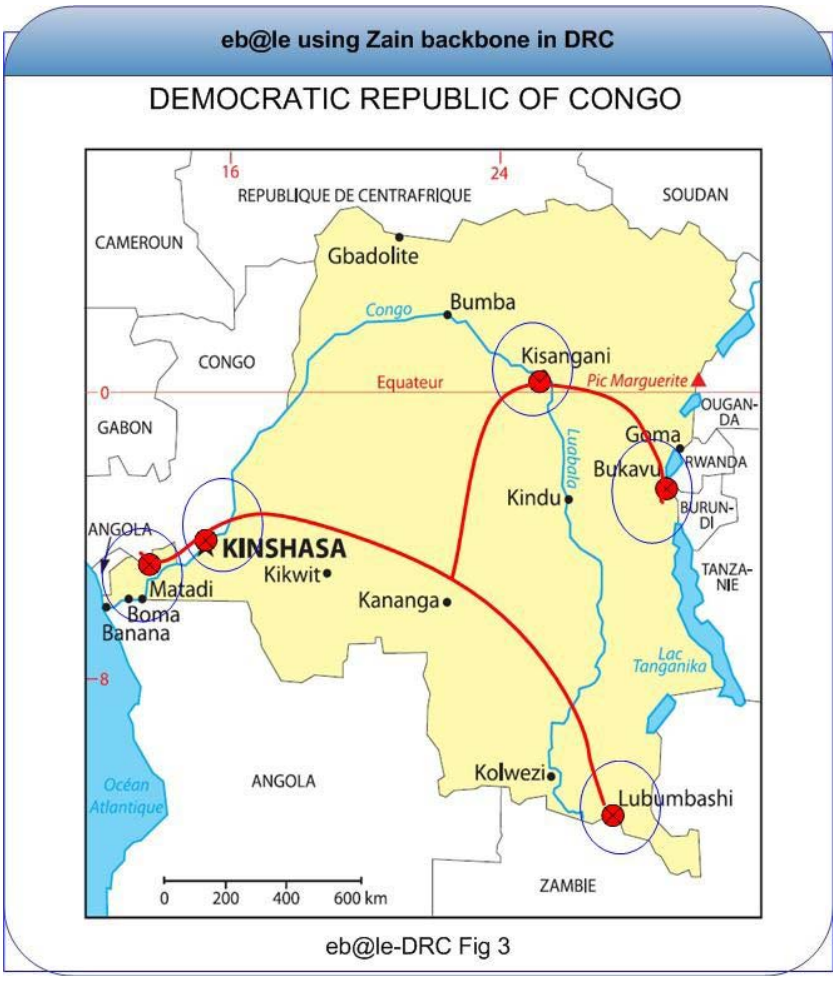
5.4. Democratic Republic of Congo

The Democratic Republic of Congo is one of the latest countries that have launched a national backbone network in 2009. The first phase of construction of a national fibre backbone involves a Muanda-Kinshasa link being built in partnership with China. The project is scheduled to last for nine months and will cost US$31 million. The link will be 651 kilometres long and have a capacity of 10 Gbps. The project is being managed by the incumbent l'Office Congolais des Postes et Télécommunications (OCPT).

The second phase will connect Kinshasa to Kenge in Bandundu province west of Kinshasa. From this province, the cable will link to the mining province of Katanga via Kasaï. No details have been announced for the routing but the path to Kolwezi passes not too far away from Mbuji-Mayi. After Kolwezi, it would go north to Bukavu (Sud-Kivu province), Goma (Nord-Kivu province), Kisangani (Orientale province), Mbandaka (Equateur province) before forming a circle through Kenge. It was noted that the cable through Katanga province will pass through Kasumbalesa which will allow a connection to be made southwards to the EASSy and other cables through Zambia.

The Muanda-Kinshasa link is expected to be completed on schedule and link to Point Noire in the Republic of Congo and Angola's Cabinda enclave and Angola. It will then become relatively easy to connect into the festoon cable in Angola. The rest of the fibre network is expected to be completed within the next three to four years through public and private partnerships.

Academic institutions are currently relying on a relatively low bandwidth network provided by the cellular operator Zain, that connects Kinshasa to Matadi, Kisangani, Lubumbashi and Bukavu (Figure 5). This will be replaced by the fibre network when it is completed.



Source: Ebale

Figure 5. Present Academic Connectivity in Democratic Republic of Congo through the Zain Network

5.5. Djibouti

Djibouti has a substantial amount of fibre connectivity compared to the rest of Africa countries and it acts as a hub for interconnection of major sub-marine cables such as SEA-ME-WE, EASSy and SEACOM. The country does not have higher education institutions that can exploit the fibre infrastructure but has potential to provide transit routes both for Eritrea and Ethiopia.

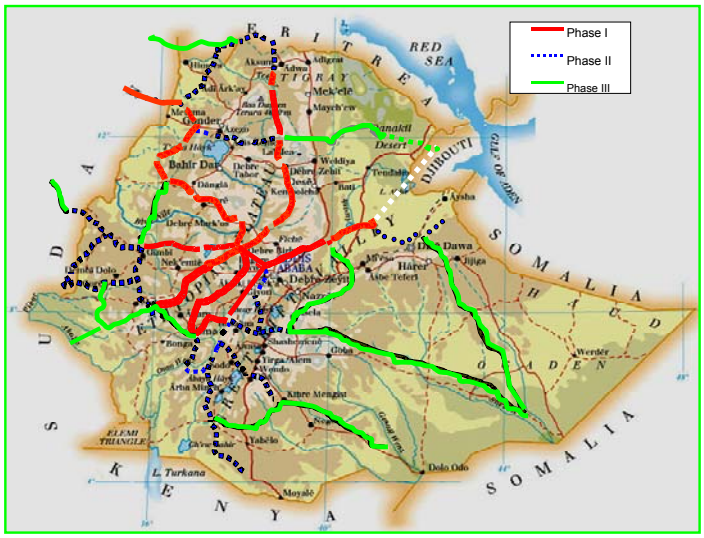
5.6. Eritrea

Eritrea has begun building fibre network to connect major towns in the recent years, but the fibre build out is not as extensive as in other neighbouring countries like Sudan and Ethiopia. It is also in the process of establishing a landing point for submarine cables when EASSy becomes operational.

5.7. Ethiopia

The government of Ethiopia, in collaboration with the Chinese company, ZTE has been building a 10,000 Km national backbone network in five directions from the capital Addis Ababa (Figure 6). The north western fibre network has links to international fibre through Port Sudan. The southern link is expected to connect to TEAMs via the Moyale town to Kenya, and the Eastern route can connect to the SEA-ME-WE, SEACOM or EASSy through Djibouti.

Ethiopia National Fibre Backbone



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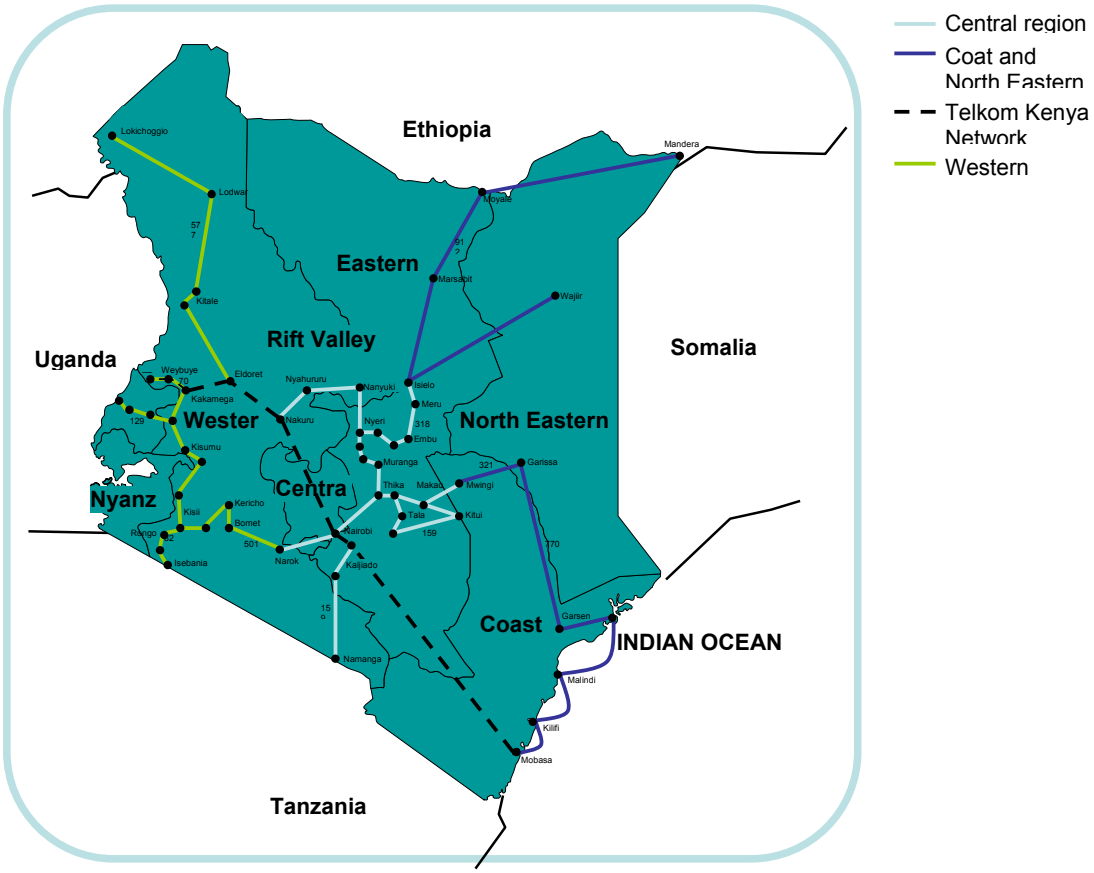
Source: Ethiopian Telecommunications Agency

Figure 6. Fibre building and Options for Ethiopia

5.8. Kenya

Kenya has made significant strides in building a national fibre network in preparation for TEAMS, SEACOM and EASSy cables. The Kenyan government has allocated US$80 million to connect all districts using a fibre network. It has also secured a loan from the World Bank to enable the connectivity of academic and research institutions through the national research and education network, KENET. In addition there are fibre connectivity initiatives by the private sector in particular the Kenya Data Network (KDN) and the utility company, Kenya Power Company Limited (KPCL). Ongoing fibre projects in Kenya are shown in Figure 7.



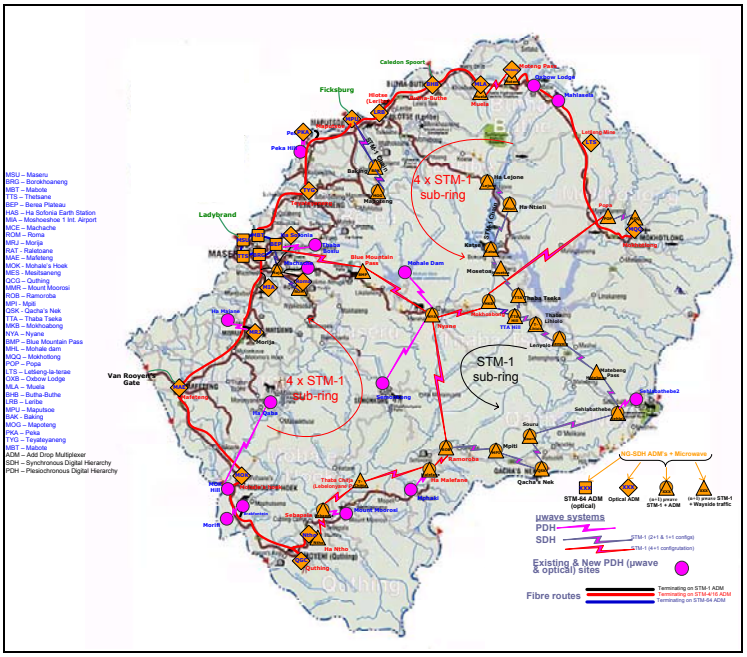
Source: Communications Commission of Kenya

Figure 7. Fibre projects in Kenya

Kenya acts a major transit hub for traffic from Rwanda, Uganda and Ethiopia.

5.9. Lesotho

Econet Telecom Lesotho ETL has launched an expansion plan for a national fibre backbone using the Next Generation Network (NGN) through a M210 million (US$ 20 million) loan from the Chinese government. The national fibre ring will cover most of the commercial centres and district capitals including Roma where the National University of Lesotho is located (Figure 8). The arrival of new international submarine fibre optic cables to the region in 2009 will bring the required international connectivity to the national backbone. Coupled with the rollout of broadband wireless network, the NGN project is expected to pave the way for availability of high-speed network to build ubiquitous health communication network countrywide at a competitive price.



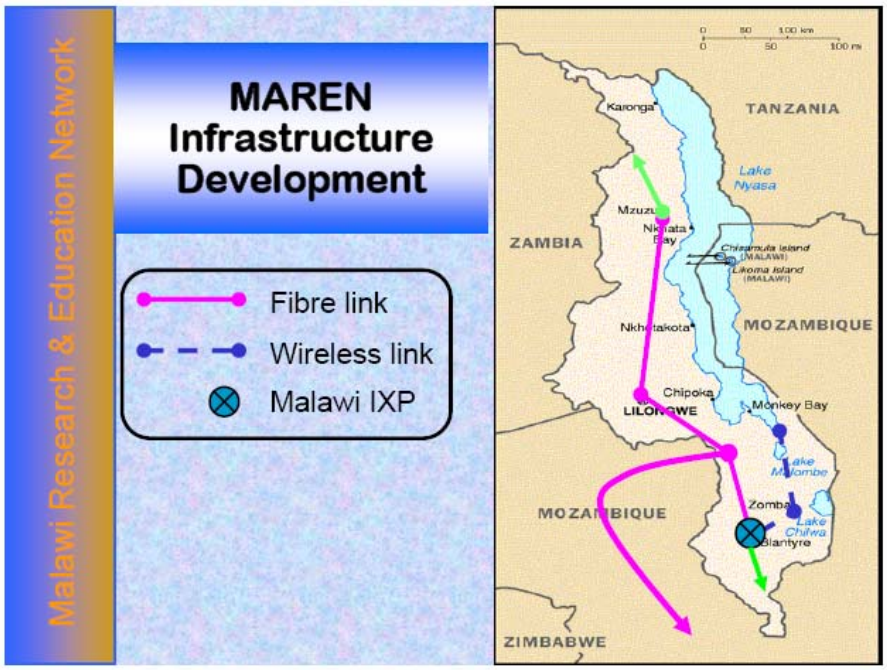
Source: Econet Telecom Lesotho

Figure 8. Lesotho National Backbone

5.10. Malawi

Malawi Telecom is in the process of building a national fibre backbone and is looking at installing a cross border fibre-optic link with Mozambique (between Mwanza in Malawi and Zobue in Mozambique); a microwave link connecting Lilongwe with Mchinji in Zambia; and extending the Mzuzu-Karonga microwave link in northern Malawi to Dar-es-Salaam. The routes the Malawi National Research and Education Network (MAREN) plans to exploit are shown in Figure 9. They plan to opportunistically exploit all other opportunities.

At the same time, the Electricity Supply Corporation of Malawi (ESCOM) has installed a fibre-optic cable on its power lines between Salima and Kanengo and has advanced plans to install a fibre-optic cable between Lilongwe and Blantyre and between Salima – Mzuzu – Karonga. ESCOM plans to eventually have a total fibre network covering 1,280 km from Blantyre to Karonga via Chintheche, Lilongwe to Mchinji in Zambia and Phombeya to Matambo in Mozambique by 2012. This will have a considerable impact on accessibility of academic institutions in Zomba, Mzuzu, Blantyre and Lilongwe.



Source: Malawi Research and Education Network (MAREN)

Figure 9. Malawi Backbone

5.11. Mozambique

Extensive fibre building activity has been underway in Mozambique by the incumbent operator Telecomunicações de Moçambique (TDM) in different phases:
- Phase 1 was the deployment of the submarine fibre between Maputo and Beira.
- Phase 2 saw the deployment of a fibre link between Beira to Quelimani.
- Phase 3 saw the commission of a link between Quelimani and Nampula.
- Phase 4 extend the network in the north to cover Quissanga, Nacala and Lichinga.

There are also other alternative fibre owners that have been active in the deployment of fibre optics networks in Mozambique:

- TVCABO, a Cable TV network provider currently owned by TDM and Visabeira, a private company with a fibre network in the capital Maputo
- EDM, the national parastatal power utility company with fibre on its power lines in Maputo and in the Southern part of the country and a 622 Mbps fibre on the Motraco power line interconnecting power stations in Maputo, Komatiport (South Africa) and Edwaleni (Swaziland).

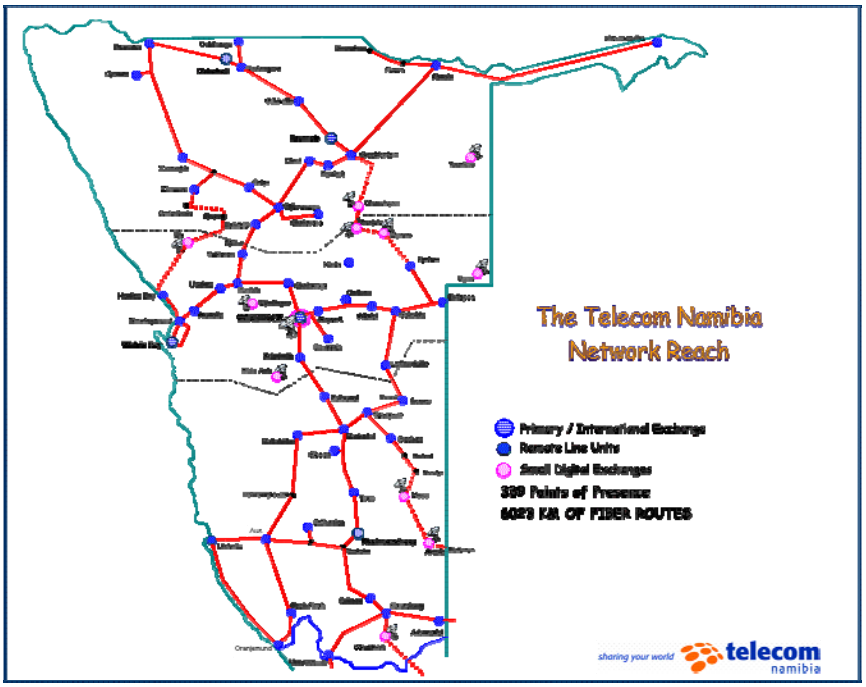
Mozambique has a significant fibre capacity (Figure 10) that will provide access to neighbouring countries such as Swaziland, Malawi and Zimbabwe, when direct links to international submarine cables such as EASSy and SEACOM are established.

Source: Mozambique Research and Education Network (MORNET)

Figure 10. Mozambique Fibre Backbone

5.12. Namibia

Namibia has one of the most advanced telecommunications backbones in Africa with an extensive fibre-optic network established by Telekom Namibia, reaching out across the entire country. NAMPOWER, the electricity company also has some fibre on its extensive electricity network. It is evident from Figure 11 that the entire country is fully covered and academic institutions will be able to access state of the art broadband network.



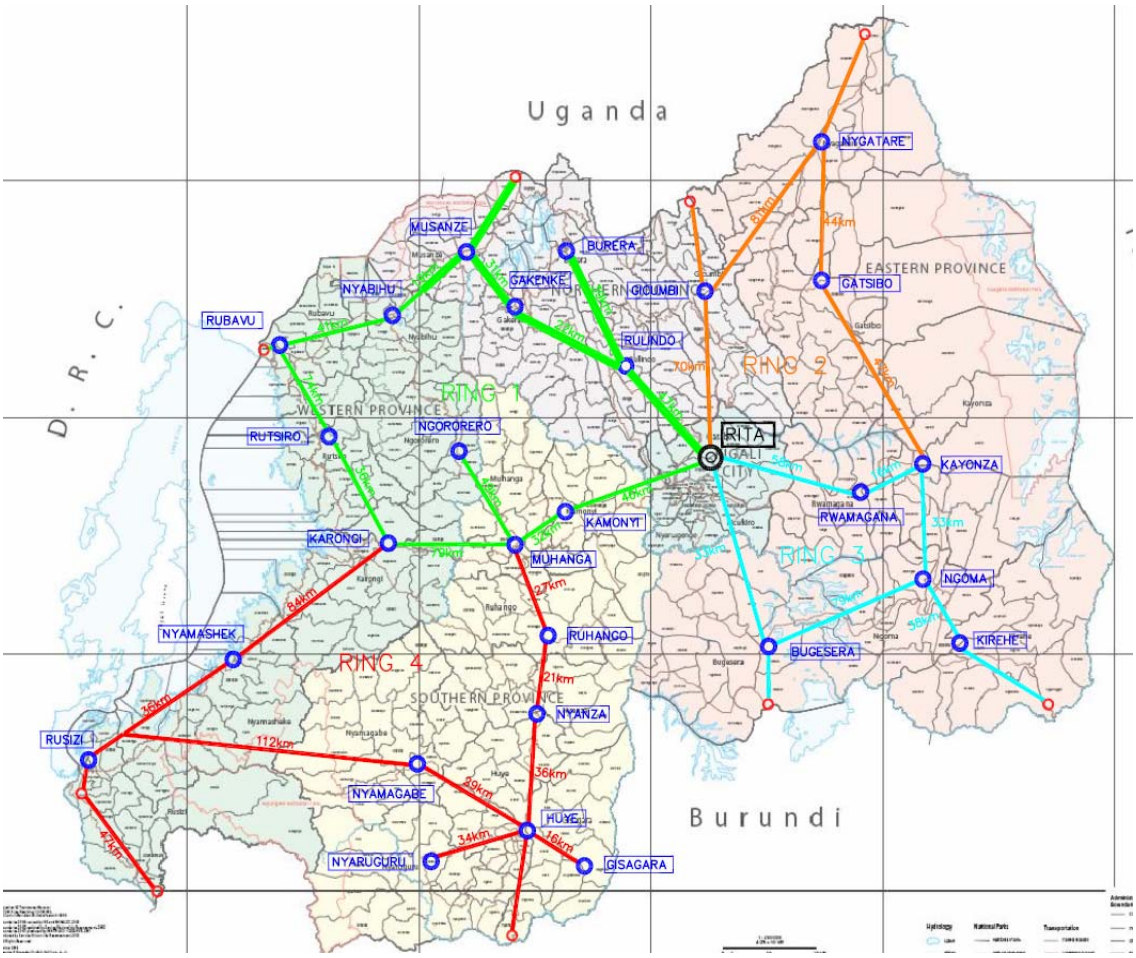
Source: Telecom Namibia

Figure 11. Telecom Namibia National Backbone

However, Namibia does not have a landing point to the submarine cable and it is working closely with Botswana and Angola to connect to SAT3 and WACS to ease the burden of the high cost of a cable through South Africa.

5.13. Rwanda

Rwanda has been one of the most active countries in terms of extending access to citizens and academic institutions. It has received support from the World Bank to develop a strategy for its national backbone and link major public and academic instiutions. The national backbone (Figure 12) aims to extend links to all major towns in Rwanda and provide onward connectivity to submarine cables through Uganda, Burundi, Tanzania and the Democratic Republic of Congo.



Source: Rwanda Education Network

Figure 12. Rwanda National Backbone

5.14. South Africa

South Africa has the best and most extensive infrastructure in the region. The state owned Telkom South Africa is partially private and the Second National Operator (SNO) Neotel has launched a series of ventures to establish fibre connectivity national and internationally. Neotel has acquired the fibre infrastructure of alternative infrastructure providers such as the electricity utility company Eskom and the transport parastatal Transnet. For international connectivity, South Africa currently relies on the SAT3/SAFE cables and now has a minimum of STM-4 (622 Mbps) links with Botswana, Lesotho, Namibia, Mozambique and Swaziland. It acts as a major hub for all submarine cable projects including EASSy, WACS and SEACOM. The Tertiary Education Network (TENET) is very active in negotiating cheaper links through the incumbent and upcoming submarine cable providers.

The Government of South Africa has also launched a broadband strategy initiative in 2008 that is expected to provide a framework for enhancing access to academic and research institutions. This started with SANREN, a 10 gigabit ring servicing major universities

around Johannesburg and Pretoria and planned, at least in concept, to eventually reach all universities.

5.15. Sudan

Sudan has an extensive fibre network rollout by incumbent Sudatel. It has a direct link to international fibre through Port Sudan (Figure 13). The Sudan University network is using the Sudatel fibre backbone for Internet connectivity. Internet access has substantially improved in the country and access to high bandwidth is common place where fibre is available. In 2008 Sudan established a fibre link to Ethiopia. There is also a potential for fibre connection to Uganda through Juba when the fibre link to Southern Sudan is completed.

National fiber track map
Source: National Information Centre

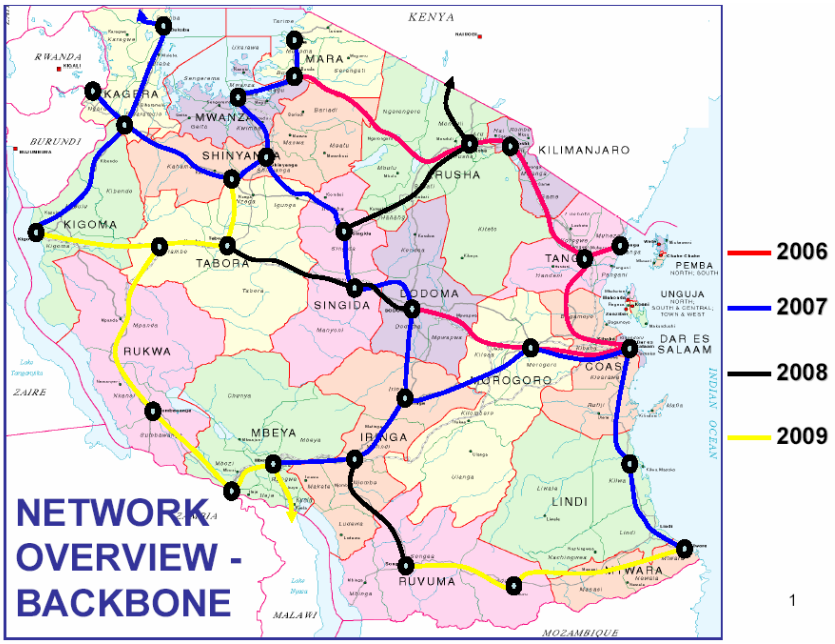
Figure 13. Sudan National Fibre Network

5.16. Swaziland

Swaziland has both digital microwave and fibre links to South Africa (from Mbabane to Johannesburg). Swaziland is also party to the Motraco fibre cable linking Mozambique, Swaziland and South Africa which is owned by the power companies of the three countries. The University of Swaziland has a potential for access to cheap bandwidth through Mozambique and South Africa when EASSy and SEACOM become operational.

5.17. Tanzania

Tanzania also has poor telecommunications infrastructure although the government has unveiled a plan to create an "ideal national backbone" through a multi-stakeholder initiative which will see the "consolidation of segments of the existing and planned Optical Fibre Cable networks from different national utility companies and the incumbent and by bridging the gaps between them". Tanzania was one of the countries that initiated a national backbone project in 2005, but has been unable to realize it for over three years: The timelines shown alongside the fibre plan in Figure 14 are therefore already at least two years behind schedule. The government is in the process of launching the national backbone project to leverage upcoming connection to SEACOM and EASSy cables. This is expected to improve the fibre network available for academic and research institutions in the country.

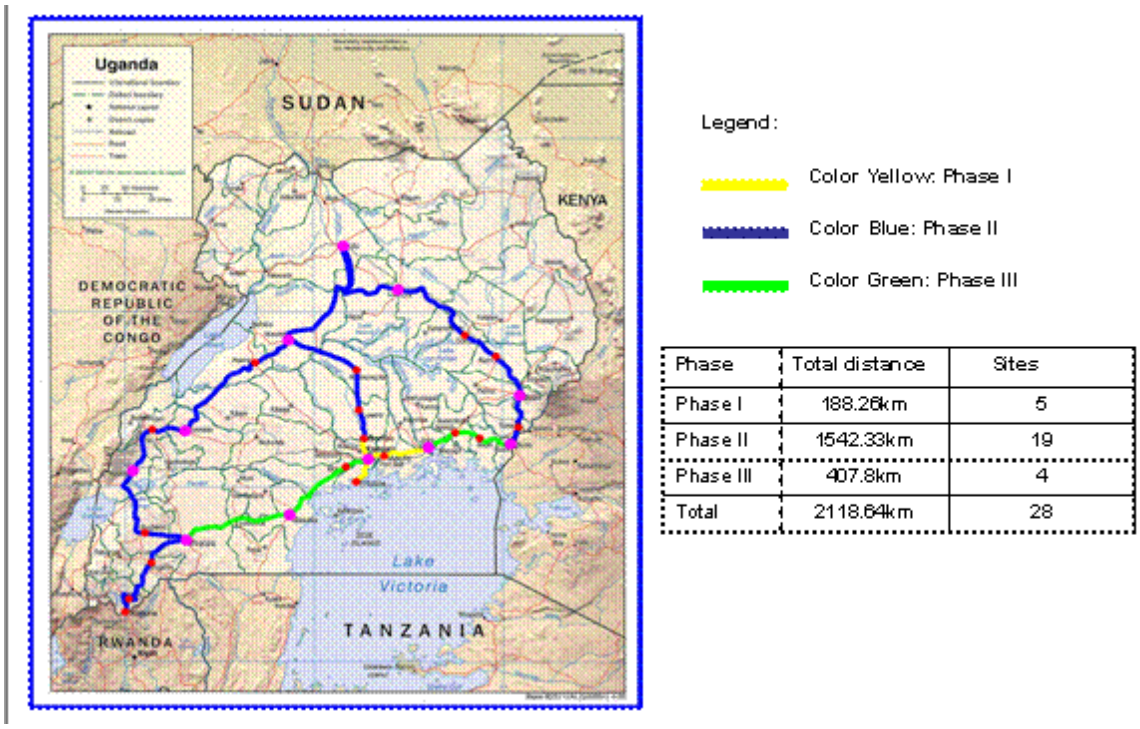


Source: Tanzania Research and Education Network (TERNET)

Figure 14. Tanzania National Backbone

5.18. Uganda

The Uganda national backbone is being built by the Government of Uganda as part of its National Backbone and E-government Infrastructure Project. This complements and supplements the rollout by service providers such as MTN and UTL. Phase 1 was completed during 2008, and Phase 2 has been approved for implementation starting 2009. The project has been funded through a combination of development funding and concessionary loan from China. This extensive network (Figure 15) is being rolled out to increase national penetration of basic and broadband services; to support e-government; and in preparation for direct link to submarine cable through Kenya and Tanzania. The Research and Education Network of Uganda (RENU) has been offered a free capacity on the national backbone.



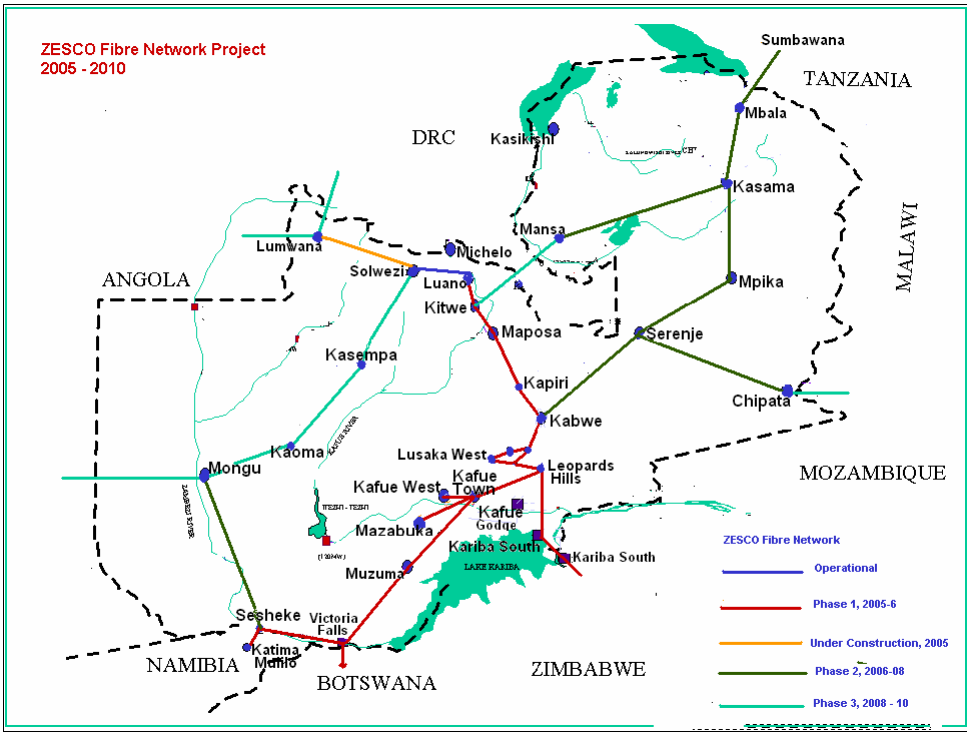
Phase	Total distance	Sites
Phase I	188.26km	5
Phase II	1542.33km	19
Phase III	407.8km	4
Total	2118.64km	28

Source: RENU

Figure 15. Uganda Fibre Network

5.19. Zambia

Zambia's State owned telecommunications company, Zambia Telecommunications Company Ltd (ZAMTEL) has bee installing a fibre-optic backbone around the country. Zambia also has two alternative fibre infrastructure providers: The Copperbelt Energy Corporation (CEC) has over 500 km of fibre-optic on its power grid in the Copperbelt region with all 220 KV sub stations connected to the network at 655 Mbps and all 66 KV substations connected to the network at 155 Mbps; The Zambia Electricity Supply Company (ZESCO) has fibre running from Katima Mulilo (Western Province) on the Namibian border to Livingstone (Southern Province) bordering Zimbabwe. ZESCO has plans to roll out more fibre across its entire network (Figure 16).



Source: ZESCO

Figure 16. Fibre by Zambian Electric Company ZESCO

5.20. Zimbabwe

The largest fibre owner in Zimbabwe is Powertel, a wholly owned subsidiary of Zimbabwe Electricity Supply Authority (ZESA). ZESA has public data network licenses and it has an STM 4 backbone capacity. The existing network runs from Harare to Bulawayo in the South of the country with plans to deploy an eastern circuit covering Mutare and Masvingo. Powertel is reportedly already leasing capacity to the Zimbabwean incumbent TelOne, and has submitted a bid to apply for a fixed-line licence.

Zimbabwe concluded an agreement with Telkom South Africa which led to the installation of an STM1 digital radio link from Gweru on the Zimbabwe side and a fibre link on the South African side. There are also possibilities for fibre connectivity between Powertel and Botswana Telecommunication Coropration fibre networks that are close to the border of two countries.

6. Conclusion

UbuntuNet countries have made significant strides in building their national backbones over the last five years in preparation for the upcoming submarine cables. Robust national fibre backbones will be available by 2012 when most of the submarine cable projects become fully operational. This is likely to improve the much needed broadband access to academic institutions. Cross-border connectivity poses significant commercial, legal and regulatory

challenges that will delay connections to landlocked countries in the region if not addressed. It is therefore essential to start cross-border negotiations well in advance before TEAMS and SEACOM links become operational.

UbuntuNet countries have ample opportunities to link to submarine cables in eastern Africa. It is essential to complete the loops between northern, eastern, southern and western Africa to establish redundant loops to ensure that packets move even if one of the submarine cable is disrupted. The northern African loop through Sudan and Egypt has a significant potential to link countries such as Ethiopia, Uganda and other neighbouring countries (Figure 17).

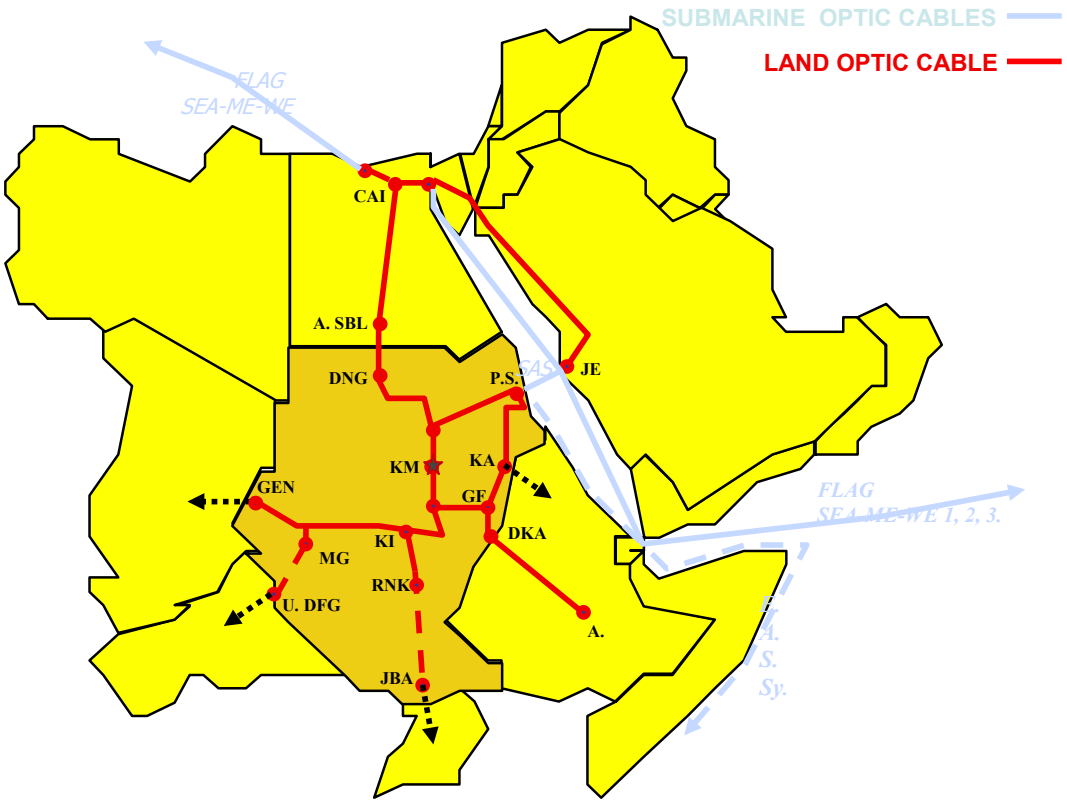


Figure 17. Potential Link to North Africa

It is essential to consolidate the opportunities provided by improved national fibre backbones and promote the exchange of experience between countries so that national backbones are built on each others' experiences and policies and regulatory frameworks are harmonized. Enhanced competition and exchange of experience will lead to a considerable reduction of cost of bandwidth that will enable academic and research institutions secure same level of connectivity to their peers in the other parts of the world.