Adding Academic Networks as an External KML Map Layer to the Web Version of the Africa Transmission Network Map

Paul HAMILTON
Hamilton Research Ltd., Bath Brewery, Toll Bridge Road, Bath BA1 7DE, UK
Tel: +44 (0)1225 852554, Fax: +44 (0)1225 852528,
Email: hamilton.paul@btinternet.com

Abstract

This is probably the world's hardest jigsaw: the Africa Telecom Transmission Map first published in 2009 by Hamilton Research represents the culmination of over seven years research and cartographic work. A high resolution version is also published on a Javascript web-based mapping platform, which is updated quarterly. To help the UbuntuNet Alliance facilitate the rapid deployment of academic networks in Eastern and Southern Africa, for network planning and maintenance purposes it would be possible to add an overlay network of academic networks including Higher Education Institutions (HEIs), National Research and Education Networks (NRENs) and Regional Research and Education Networks (RRENs) on top of this web-based map using the KML format. This would leverage the mapping work which has already been done, and allow the UbuntuNet Alliance to concentrate on developing detailed maps of academic networks for use by its community.

The web version of the Africa Transmission Map is published in the password-protected client area of the Africabandwidthmaps.com website, and is provided to customers on a single-user and multi-user annual subscription basis. The KML format is by its nature designed to be put in the public domain, and can be used in Google Earth desktop application and Javascript API web maps. Because it is possible to add a KML file as a selectable layer into Javascript API web maps, a map of academic networks can be superimposed as an overlay network on top of the Africa Transmission Map. This can be used as a network planning tool to assist NRENs and RREN in building national and regional networks. The same KML file can be published for download to be used in Google Earth, or a public Javascript web map, to be shared with its whole community.

Keywords
Map. Transmission Networks. Fibre. KML. Javascript. HEI. NREN. RREN.

1. About the Africa Telecom Transmission Map

The Africa Telecom Transmission Map[1] shows the terrestrial fibre and microwave, submarine cable transmission networks for 113 operators in 54 African countries. It also shows major network nodes, GSM coverage, Internet Exchange Points (IXPs), and the pattern of international Internet bandwidth.

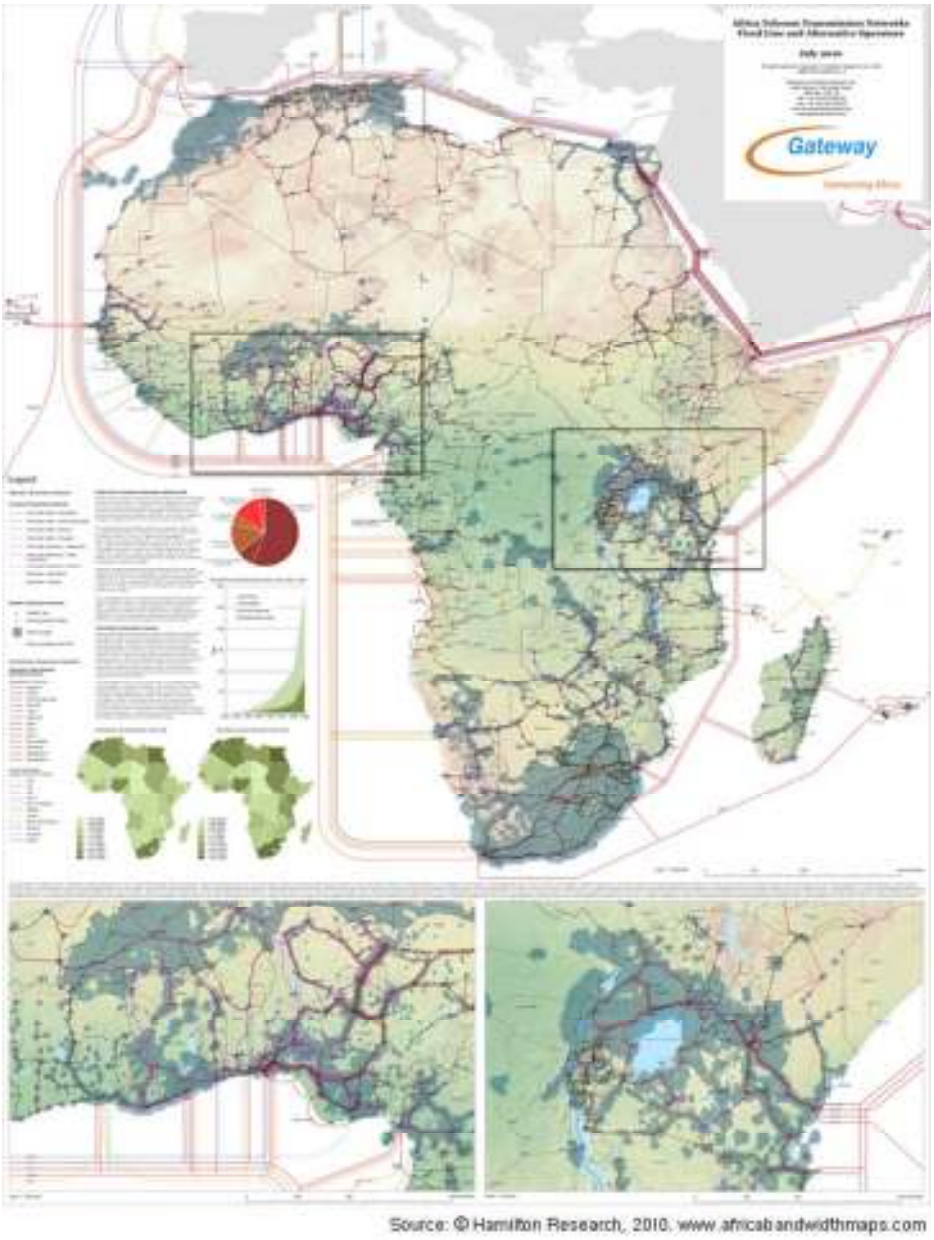

Figure 1: 2010 Africa Telecom Transmission Map

1.1. Inventory of Transmission Networks

[1] "2010 Africa Telecom Transmission Map", published by Hamilton Research, ISBN 978-0-9562970-1-3 Available at: http://www.africabandwidthmaps.com

The two maps below show the speed with which fibre networks have been deployed in the year to July 2010. The poster map is published once a year, and the web version of the map has been updated quarterly since Q3 2009.

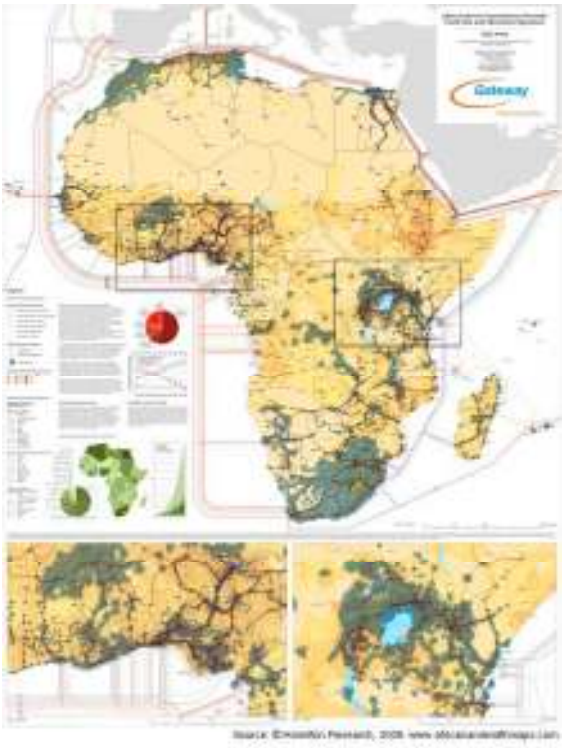

Figure 2: 2009 Africa Telecom Transmission Map

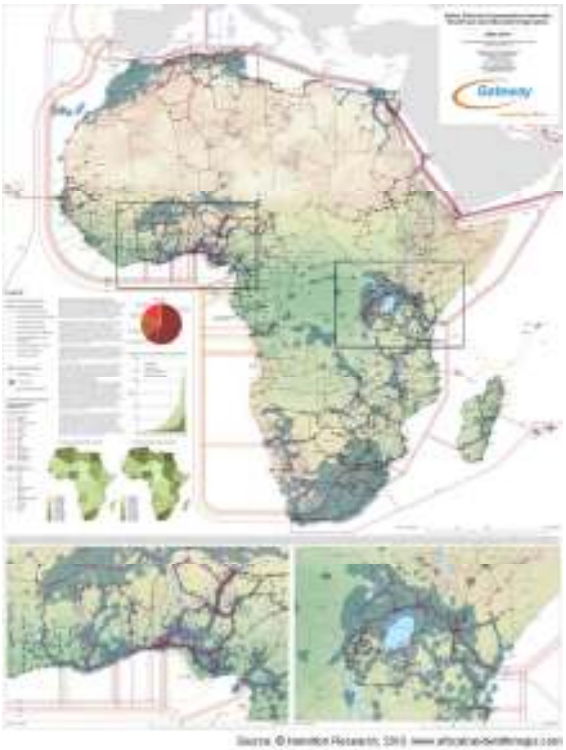

Figure 3: 2010 Africa Telecom Transmission Map

Key findings:

- By July 2010 the map shows a total inventory of 585,471-kms of network infrastructure. Laid end-to-end that is enough to wrap around the earth 14.6 times.
- In July 2009, there was 465,659-kms, a 26% increase in one year on a like-for-like basis. (The 2009 map shows 401,282-kms, but was rebased to include additional network not previously shown).
- In 1987, there was around 74,000-kms of microwave network.
- The total length of operational network (rather than under construction, planned or proposed) was 411,686-kms. This was an increase of 57,560-kms compared to July 2009. Laid end-to-end, that is enough to wrap around the earth 1.5 times.
- In addition, a further 44,651-km was under deployment as at July 2010, over 5,000-kms of which entered service during the third quarter.
- Africa's international Internet bandwidth surpassed the 300 Gbps mark in the first quarter of 2010, and Sub-Saharan Africa surpassed the 100 Gbps mark.
- The completion of new cross-border links, and expansion of capacity on others, has seen the volume of intra-regional traffic to submarine cable landing stations increase to over than 10 Gbps. The activated capacity on cross-border networks is increasing, from STM-1 circuits to 2 x STM-1, becoming STM-4 and beyond.

1.2.Production

The Africa Transmission Map is produced using ESRI ArcView GIS software v10.0. Operator's transmission networks are added into the map in a variety of ways depending on the format in which it is provided, in same cases using native GIS files, in others by plotting co-ordinates and joining the dots, and in others by hand-drawing on the basis of named waypoints provided. Prior to the first publication in 2009 we underwent a clearance process to ensure that we had permissions to publish this data.

There are now over 5,000 separate links and 3,000 nodes contained in the map. On average each quarter several hundred links and nodes are updated or new entries made. Each separate link (from node A to node B) is recorded as an individual polyline. The map is attached to an underlying database, in which as much technical detail of that individual link is recorded, including country, operator, Node A, Node B, capacity, length, type, operational status, date and a section for additional notes.

This database approach enables the map to be a "live" map, its status is continually updated by editing the underlying database rather than having to restyle each individual line manually and separately whenever there is a change. By keeping a rolling record of these developments it is also possible to track the status of network roll out in route-kms by country, operational status and so on.

1.3.Background

The first iteration of the transmission map came in 2002, published in the AITEC African Communications Infrastructure and Services Report 2002/3[2], showing the relationship between submarine cables, satellites, regional fibre projects and international bandwidth. In Chapter 5, the report contained an inventory of submarine cables and regional fibre connectivity projects, which was compiled into a year-by-year powerpoint presentation comparing the deployment of network infrastructure against international bandwidth.

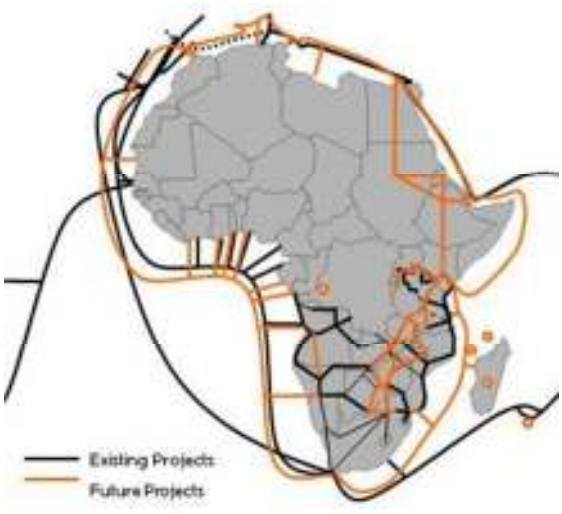

Figure 4: Existing and Future Fibre Connectivity Projects 2002

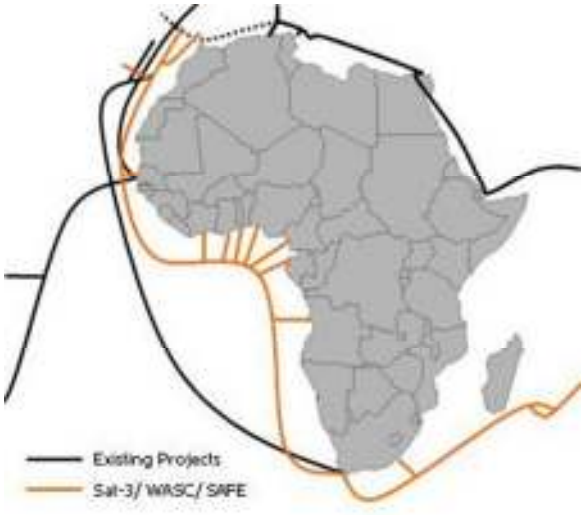

Figure 5: Existing Regional Submarine Cable Projects 2002

[2] P. Hamilton, S. Moroney, A. Opoku-Mensah, M.Mureithi, M. Jensen, R. Southwood "The African Communications Infrastructure & Services report 2002/03", Aug.2002.

We are grateful to the International Development Research Centre (IDRC) for producing the Internet Out of Africa (2003) and Open Skies satellite coverage (2004) maps, and commissioning the Acacia Atlas[3] in 2005. The Acacia Atlas contained a later version of the transmission map in its centre pages, and notably also a section on Academic Networking presenting some of the findings of the Promoting African Research and Education Networking (PAREN) study.

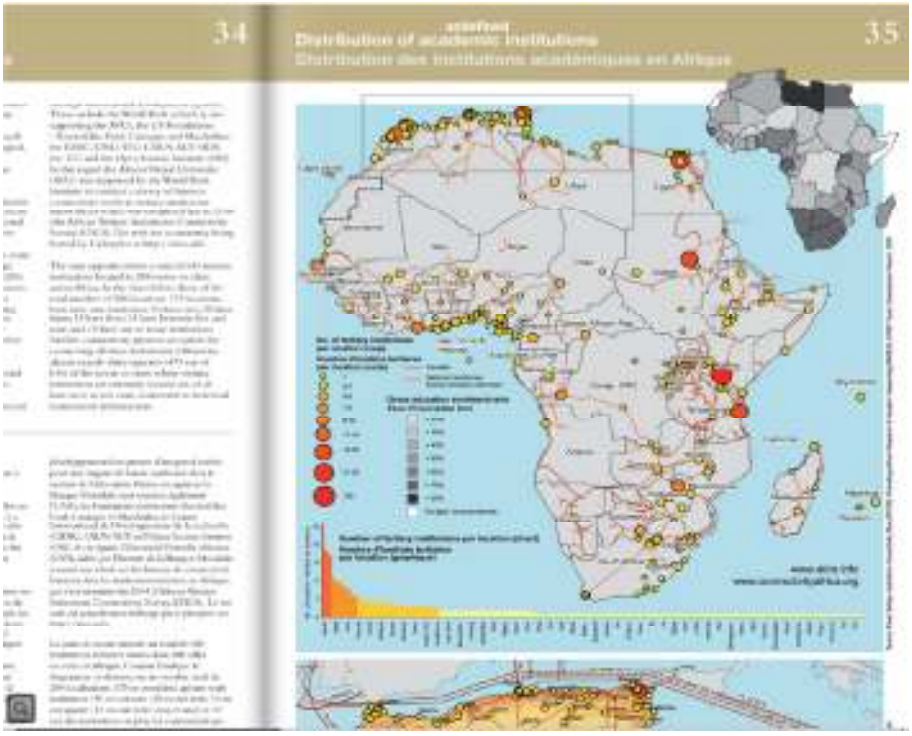

Figure 6: Bandwidth and African Universities, The IDRC Acacia Atlas 2005

1.4. Sources and funding

The development of the Africa Transmission Map has been a long-term project, which has taken over seven years to research and produce. It is an open ended project in the sense that it is requires continual maintenance in order to remain accurate and up-to-date. It will never be finished, as it is constantly going out of date. The map's existence relies on the support of dozens of network operators, consulting firms, industry associations, financial institutions and regional organisations including ECOWAS, ECCAS and NEPAD which have generously provided information and updates over the years. We have undertaken consulting work for a number of organisations regarding African transmission networks, but the Africa Transmission Map itself receives no public funding. Its viability is therefore supported by sponsorship, sales and subscriptions, the revenues from which support the map's continued maintenance and development. We are grateful to Gateway Communications for agreeing to sponsor the map in both 2009 and 2010.

2. Web Based Version of the Africa Telecom Transmission Map

[3] "The IDRC Acacia Atlas 2005: Mapping African ICT Growth", Oct.2005. Bandwidth and African Universities p.34, Distribution of Academic Institutions p.35.http://www.idrc.ca/acacia also available at http://www.africabandwidthmaps.com/?page_id=78

We purposefully do not make electronic versions of the map available, for two reasons. First, the existence of the map in PDF, KML or other high resolution easily disseminated format would jeopardise the viability of continuing to produce the map. Second, many operators are sensitive about the level of detail of their physical networks which is put into the public domain, for a number of concerns. However, in the third quarter of 2009 we published the first web-based version of the transmission map in a manner which satisfies these concerns. After analysis of the various Javascript APIs available, the OpenLayers API was chosen as the most suitable for the purpose. The web map is available to customers on an annual subscription basis, with discounted multi-user subscription options available.

Figure 7: Rolling Transmission Map, Hamilton Research http:www.africabandwidthmaps.com

2.1. Web-based GIS and Javascript APIs

There are many implementations of Geographic Information System (GIS) on the web, many of which required the specialised hosting on a dedicated GIS server. The development of Javascript mapping APIs has really revolutionised the field, and was really opened up by Google Earth and Google Maps which are the most well known. There are at least 6 Javascript APIs, Javascript libraries which invoke commands to render maps in your browser, and others include: Yahoo, Microsoft (Bing Maps), Openlayers, Michelin and so on. These enable both GIS and non-GIS data to be displayed on robust, lightweight maps on web pages. Each API has its pros and cons, both in terms of functionality and licensing. The different APIs are notably subject to different terms of service, which both developers and providers need to be familiar with and comfortable using. We have chosen to use the OpenLayers API for the Africabandwidthmaps website because it fits our requirement best.

2.2. Zooming and Scale

One of the key tasks of cartography is accounting for scale; to show as much granular detail as is required at different scales. This involves striking a balance between making the map as useful as possible by showing relevant information, but also readable. On the one hand it would be possible to show the labels (names) for all towns and villages when you look at the whole continent, but the map would become a mess of typeset characters that would prevent you from reading anything on it. On the other hand, if you were to zoom in close and only had the labels for capital and major cities showing this would not provide enough information to provide any detail. For this reason, standard conventions are used to incrementally display greater levels of detail at different thresholds. For example, only the names of countries appear at a first scale, then capital cities at a second, major cities at a third, towns at a fourth, and villages at a fifth.

We have developed three web versions of the Africa Telecom Transmission Map, each with different features and showing more granular levels of detail at different scales. The first "Rolling Transmission Map" shows all networks to a scale of 1: 1,560,000 (1cm = 11.56 km), and network nodes when zoomed in to the closest scales. The Silver Transmission Map also shows an additional map layer showing the range (in kilometres) from these nodes, and the labels of nodes (> 3,000 nodes). In addition, the Gold Transmission Map also shows labels for operators (>5,000 labels).

3. The UbuntuNet Alliance for Research and Academic Networking

The UbuntuNet Alliance for Research and Education Networking was established to capitalise on the emergence of optical fibre and other terrestrial infrastructure opportunities to become the Regional Research and Education Network (RREN). Established and emerging NRENs (National Research and Education Networks) in Kenya, Malawi, Mozambique, Rwanda and South Africa came together as the Founders of a new grouping: the UbuntuNet Alliance for Research and Education Networking. The vision of delivering very high speed - gigabits (Gb/s) connectivity instead of the current kilobits (kb/s) between African Universities and Research Institutions is driving the Alliance forward at a rapid pace. The founding NRENs have been joined by DRC, Sudan, Tanzania, Uganda, Zambia and most recently Ethiopia and SomaliREN[4].

The development of this RREN and NREN networks depends on the availability of fibre transmission networks within and between different countries in order to interconnect Higher Education Institutions (HEIs). NRENs and RRENs will purchase capacity in IRU (indefeasible rights of use) or as leases from the network operators which own and operate these networks. Given the capacity requirements of HEIs, NRENs and RRENs become important anchor tenants for these operators.
In pursuit of this goal the UbuntuNet Alliance developed and in July 2010 published its own fibre map of Africa in PDF and KML format. Given the time and resources required, and open-ended nature of such an endeavour, I would offer to suggest realigning this project to develop a detailed, live map of academic networking in Africa.

Such a map might contain three layers, and their underlying data:

[4] Source: UbuntuNet website: http://www.ubuntunet.net/

- **Locations of HEIs:** Plot the locations of African HEIs as points (nodes). Match HEI locations against database of HEIs connectivity requirement. For example in West and Central Africa, the AAU compiled a database of HEI connectivity which could be linked to the map, to show HEI demand by users, bandwidth requirement and so on. For example the map shown below plots the results from 51 HEIs surveyed in the AAU Connectivity Survey[5] against the Africa Transmission Map.

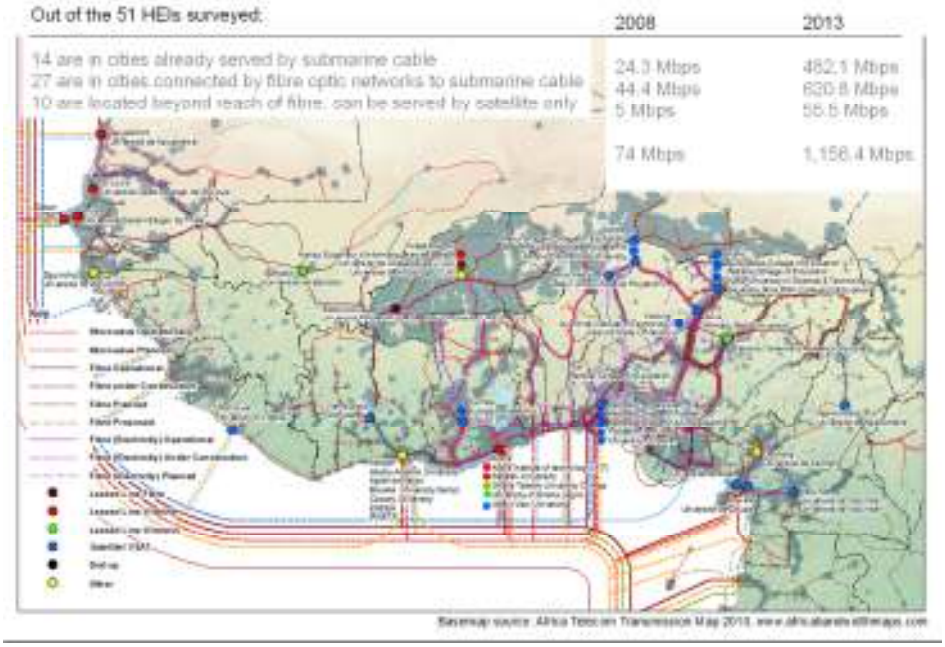

Figure 8: AAU Connectivity Survey: Addressing the Demand for Connectivity of HEIs in the West and Central Africa Region (map updated in October 2010).

- **NREN Connectivity:** Produce a detailed map layer of NREN connectivity (links), showing the current and planned national network links between HEIs. This file can contain technical data on the amount of capacity purchased or leased, network status and so on.

- **RREN Connectivity:** Produce a detailed map layer of RREN connectivity (links), showing the current and planned regional network links between NRENs, and onward connectivity by satellite or on submarine cables to RRENs such as Geant. This file can contain technical data on the amount of capacity purchased or leased, network status and so on.

4. Adding KML Layer of Academic Networks to the Africa Transmission Map

The web version of the Africa transmission supports the loading of external KML files as an overlay superimposed on top of the base layers. This has already been done for one client, is tested, stable and now in use. It is therefore possible to add KML file(s) showing HEIs, NRENs and RREN regional connectivity network as overlay(s), which is/are maintained, updated, published and hosted by the UbuntuNet Alliance. These KML files can be updated on a regular basis, to show a rolling update of academic network connectivity (nodes and links) as the network(s) evolve, capacities are upgraded, and an increasing number of HEIs are connected.

[5] Source: http://events.aau.org/content.php?id=14&/lang=en&mid=12

This will initially show dozens of links, which will grow into hundreds as more planned networks become operational.

The KML format contains a number of properties, such as related information for each object, which are hard-wired as static information into the file. By connecting the KML file to an underlying database and/or using network links for example, this map file can be more efficiently and dynamically kept up to date, by maintaining the underlying database. The KML file(s) and/or underlying database could potentially therefore show all African HEIs, their co-ordinates and demand requirements, the current and planned national (NREN) and regional (RREN) network links with their capacities and status.

These KML files can then published in the public domain for the whole academic networking community to use. They can be made available as KML file for downloading into Google Earth, placed into a Javascript API such as Google Maps, and/or published as PDF or other documents. Each format has its own pros and cons, for example using a Javascript API platform would enable the streaming of news items through the map ("South Africa: SanRen Network Completed") and so on. Another advantage of publishing through a Javascript API is that the map which is shown can always be the current version.

The KML files can also be compared against the underlying Africa Telecom Transmission network map to show which of the physical links have become operational or have become feasible over time. This can be used for network planning and maintenance purposes by the technical staff of NRENs and the UbuntuNet RREN. This would be a customised web version of the Africa transmission map which contains the KML file(s) hardwired into them. This customised map would be contained in the password-protected client area of the Africabandwidthmaps website, and provided on a discounted multi-user subscription basis. The KML files themselves will continue to be owned, maintained and hosted by the UbuntuNet Alliance, but appear as a selectable overlay in the transmission map.

References

[1] "2010 Africa Telecom Transmission Map", Hamilton Research, ISBN 978-0-9562970-1-3. http://www.africabandwidthmaps.com

[2] P. Hamilton, S. Moroney, A. Opoku-Mensah, M.Mureithi, M. Jensen, R.Southwood (2002)"The African Communications Infrastructure & Services report 2002/03".

[3] "The IDRC Acacia Atlas 2005: Mapping African ICT Growth", Oct.2005. Bandwidth and African Universities p.34, Distribution of Academic Institutions p.35. http://www.idrc.ca/acacia also available at http://www.africabandwidthmaps.com/?page_id=78

[4] UbuntuNet website. http://www.ubuntunet.net/

[5] P.Hamilton. (2010) "Addressing the Demand for Connectivity of Higher Education Institutions in the West and Central Africa Region", paper presented at High Level Conference on the Connectivity of West and Central African Higher Education Institutions: Providing Adequate and Affordable Bandwidth to African Higher Education and Research Institutions,

African Association of Universities (AAU) research and Education Networking Unit (RENU), Accra (Ghana) 18 – 19 October 2010.
http://events.aau.org/content.php?id=14&/lang=en&mid=12