

# Developing Appropriate Research Services for Kenyan Researchers

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## Abstract

Emerging African National Research and Education Network build and maintain advanced broadband networks that interconnect universities and research institutes<sup>1</sup>. The NRENs not only provide basic Internet and shared services but are also considered part of the national innovation and research system in some African countries<sup>2</sup>. In order to achieve their mandates, emerging NRENs must develop appropriate research services for users in research universities and research institutes<sup>3</sup>. This paper will describe the initial community cloud based research services that KENET has been providing as well the new advanced research services that will leverage on European and African research infrastructures accessed through NRENs. The paper will describe the ongoing work of establishing and operating a KENET Certificate Authority and an identity provider that will allow Kenyan researchers to access the African Grid Science Gateway and other high performance computing facilities in Africa and Europe. This means that Kenyan researchers and doctoral students will have access to advanced research labs and facilities from any of the connected campuses. The paper will describe the ongoing work of promoting the use of these infrastructures by the Kenyan academic community and building the specialized technical capacity within KENET for supporting these new advanced services.

**Keywords:** National Research and Education Network, Kenya Education Network, Science Gateway, Cloud based research services, Certificate Authority

## 1. Introduction

The Kenya Education Network Trust (KENET) is a not-for-profit membership organization that is licensed by the Communications Authority of Kenya as an Alternative Network Facility Provider<sup>3</sup>. It is the National Research and Education Network (NREN) of Kenya and provides broadband Internet services to the higher education and research community in partnership with other licensed telecommunications operators. It also conducts ICT research in education and pilots innovative learning technologies in collaboration with faculty and students in member institutions. KENET has been developing appropriate research services for Kenyan Researchers as described this paper.

KENET had connected 152 campuses of higher education in 32 counties in Kenya as of October 2014. The campuses have a combined student enrollment of over 500,000 and the network serves both the faculty and the students. The KENET network has a national distribution capacity of over 25 Gb/s and generates about 5.0 Gb/s of international Internet traffic<sup>4</sup>. It is therefore one of the largest IP networks in Kenya with direct peering with other NRENs in Africa and the rest of the world. Some of these NRENs include TENET in South Africa, GEANT in Europe and Internet2 in the United States of America.

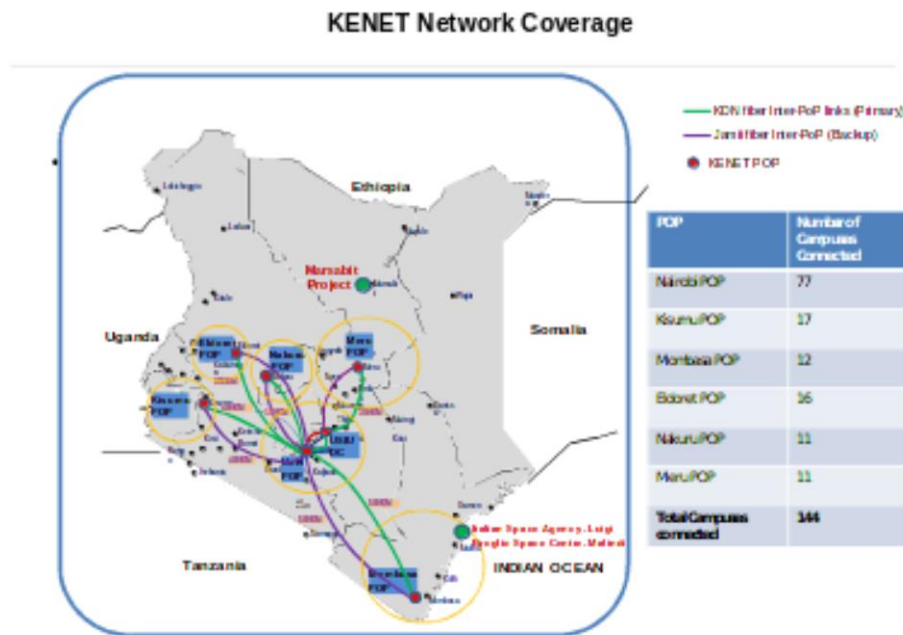


Figure 1: KENET backbone network coverage

The broadband provided to the institutions promotes collaboration between researchers both within the country and across the globe. Some of the institutions connected by KENET are purely research institutions that use the broadband both for research and also for uploading and downloading research data to central databases that are located in different parts of the world. There are thirteen (13) member research institutes connected to the KENET network that are either international or national or both. Some of these research centers include Luigi Broglio Space Centre (BSC) in Malindi which is used for satellite tracking and communications, the International Livestock Research Institute (ILRI) which works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock, ICIPE—African Insect Science for Food and Health that does research on insects effects on human, livestock and crop health, KEMRI (Kenya Medical Research Institute) which is a leading health research institution in Africa. All these research institutions partner with other bodies globally. They also share databases to researchers from different parts of the world. The collaboration is made possible by the KENET broadband network.

Research universities in Kenya such as University of Nairobi (UON), Kenyatta University, Jomo Kenyatta University of Agriculture & Technology (JKUAT), Egerton University among others use the KENET network to aid in their research work. Examples include the

Bio-informatics centre at UON, the Nairobi industrial & Technology Park at JKUAT and horticultural and Agricultural research at Egerton University among others.

Universities and other research institutions prefer to use the KENET broadband network as opposed to the commercial Internet Service Providers due to a number of factors among them the peering with other Research Networks in Africa, Europe and North America. In addition the KENET network has low congestion and high availability. It also provides an allowance for bursting for research data traffic and during off-peak hours.

The following section describes the research services that KENET has developed and provides to the research community in Kenya.

## 2. Community cloud based research services

KENET runs a community cloud service dubbed the 'KENET shared services' for its research community. Some of the shared services include virtual hosting, co-location and community research groups through mailing lists. In order to provide the community cloud services, KENET operates two Tier 3 data centers located at different universities in Nairobi. These data centers have high availability with redundant power sources, redundant UPS, air conditioning and server racks that can be used for co-location of equipment. With the KENET co-location service equipment, space, and bandwidth are available for rental to universities and researchers. This service is especially for those universities/researchers that do not have a well developed campus network or those whose last mile connectivity is not good.

### 1.1 Virtual Hosting

#### 1.1.1 Virtual private servers (VPS)

A Virtual private server (VPS) is a type of web hosting server where hosting is done by segregating a main physical server into multiple virtual servers with each server in the system getting its part of resources based on custom requirements. Each part of this VPS has capabilities of performing independent operations with its own operating system and hardware resources dedicated to it. VPS offers great choice of customization and flexibility to manage and restructure resource and is normally recommended for universities or researchers who want to host research projects data, websites or even repositories. There are several reasons why researchers prefer the use of virtual private servers. They include:-

- i. **Affordability and speed of deployment:** The cost of virtual servers is a small fraction of purchasing dedicated servers for research. The servers can also be procured on short notice and deployed rapidly for the duration of a research project
- ii. **Scalability:** Researchers can easily upgrade the servers depending on research needs.
- iii. **Security:** All VPS machines are provisioned as per the KENET security policy. Their use is also governed by an Acceptable Use Policy (AUP) In addition; the KENET team of cyber security staff ensures that the servers are operated in a secure manner.

#### 1.1.2 Dedicated Servers

For researchers with adequate budgets for server for some period of time, KENET provides the option of obtaining a dedicated server. This is more flexible than shared hosting, as the

researchers have full control over the server(s), including choice of operating system, hardware, etc. For example, the 'TUSK Server' deployed in 2012 supports the collaboration of three medical schools, namely, Moi University medical school in Eldoret 350 KM from Nairobi, the University of Nairobi medical school in Nairobi and the Tuft University Medical School in Boston, USA. The server supports an e-learning platform for the medical researchers and students known as the TUSK (the Tufts University Science Knowledge base).

## **1.2 Internet Measurement lab**

KENET hosts the Internet Measurement lab (M-lab) at one of its data centers in Nairobi (the Nairobi Node). The M-Lab provides a large collection of open Internet performance data such as visualizations of network performance, network transparency and the network state (see <http://www.measurementlab.net>)

As a consortium of research, industry, and public interest partners, M-Lab provides an ecosystem for the open, verifiable measurement of global network performance. Researchers can deploy open source Internet measurement tools. The data collected by those tools is released in the public domain. The goal of M-Lab is to advance network research and empower the public with useful information about their broadband and mobile connections. By enhancing Internet transparency, M-Lab helps sustain a healthy, innovative Internet.

KENET engineers use the M-lab measurement tools for measure the quality of links in its national distribution network. There are also many users from outside Kenya and Africa but KENET has not yet been monitoring the users. KENET intends to promote the M-LAB as a research infrastructure that can be used by researchers and policy to measure the quality broadband Internet deployment in Kenya.

## **3. Research collaboration Platforms**

### **1.1 Mailing lists and discussion forums**

In order to promote research through collaboration, KENET has identified various research communities and setup research groups that use mailing lists and discussion forums for communication. The mailing lists are moderated by KENET and vary from administrative to purely research mailing lists. A mailing list is a collection of names and addresses used to send material to multiple recipients. Some of the research mailing lists run by KENET are innovation champions, health experts, librarians, network administrators, research assistants among others

### **1.2 Video and web conference**

KENET has video conference equipment located at different locations across the country. These sites include Nairobi, Nakuru, Eldoret, Kisumu and Mombasa which also serve as Points of Presence (POPs) for the KENET network. Researchers can go to any of these sites and participate in a video conference with other researchers or students across the globe. Some of the documented usage of the video conference includes cases where researchers have used the facility to submit and explain proposals for project funding and students presenting PhD theses.

Researchers use the video conference facility either by doing a point to point call between different sites or by creating a conference room where others can join. For the latter, KENET

has installed a bridge at its data center where different end points connect. For those who want to use web based video conference, KENET has setup Big Blue Button system which is an open source web based solution to video conferencing.

## **4. Advanced Research Infrastructures**

Universities and research institutions in Kenya have published portals, repositories and databases of their research. An authentication to these e-resources is required by the universities. Additionally there are high performance computing infrastructures across the globes that are useful especially to the doctoral students and research institutions. In order to access resources in these infrastructures, a trusted entity is required to provide authentication services. KENET has therefore setup Certification Authority (CA) and identity provider (IdP).

### **1.1 Technical implementation**

KENET partnered with other NRENs in Africa specifically TERNET from Tanzania, SAGrid/SANREN from South Africa and NgREN from Nigeria to develop a Federated Identity Service to access the Africa Science gateway<sup>4</sup>. The service is used by the higher education community in these countries to access E- infrastructures that use distributed computing infrastructures within and outside the continent. The collaboration was facilitated by the ei4Africa project. eI4Africa is a FP7 project funded by the European Commission (DG CONNECT) with the aim of boosting the Research, Technological Development and Innovation (RTDI) potential of African e-Infrastructures and to support policy dialogues and Euro-African cooperation in the framework of the joint Africa-EU Strategic Partnership on 'trade, regional integration and infrastructures' (JAES Partnership 3) as well as the Joint Africa-EU Strategic Partnership on 'science, information society and space'. The system consists of the following:-

- A certificate authority (CA) that issues and verifies the digital certificates.
- A user database that stores user details with a web interface for user registration and approval
- An identity provider which acts as a 'single-sign in', or logging-in system for computer networks and the Internet
- Africa Science gateway

The setup process involved setting up of the Certificate Authority, the user database, identity provider and the user registration interface in that order.

### **1.2 The KENET Certificate Authority**

The KENET CA is a fully functional Certification Authority capable of issuing one year personal and robot public key certificates (compliant with the X.509 standard). Users can request for personal certificates, host certificates, renew and check certificate revocation lists. Certificates issued by the KENET CA have been tested and are supported by Mozilla, Chrome and Internet Explorer.

The system is installed on a CentOS Linux box running tomcat6 Apache server. Once a user requests for a certificate an email is send to both the user and the CA administrator indicating a request has been made. Upon receipt of the email, and upon verification of the user, the CA administrator logs into the CA system and signs the requested certificate. The signed certificates (both the private and public) are then send to the user and are ready for

installation either on servers or on the browsers depending on the type of certificate requested.

### **1.3 KENET user database**

To facilitate authentication and authorization of users, a database of users is necessary. OpenLDAP which uses the LDAP protocol is an open source tool for creating user directory was setup on a CentOS Linux box. Lightweight Directory Access Protocol (LDAP) is an Internet protocol (runs over TCP/IP) used to access information directories. For easy management of the OpenLDAP, a web based OpenLDAP management system was setup. This is because the OpenLDAP on its own is terminal based hence not user friendly to non technical people. The web interface provides a platform where users can register. The OpenLDAP administrator can approve, suspend and delete users from the user database.

### **1.4 KENET Identity Provider**

Federated identity allows for information about users in one security domain to be provided to other organizations in a federation. This allows for cross-domain single sign-on and removes the need for content providers to maintain user names and passwords. Identity providers (IdPs) supply user information, while service providers (SPs) consume this information and give access to secure content. The KENET IDP is developed using Shibboleth which is open source software and released under the Apache Software License.

### **1.5 Africa Grid Science Gateway**

The Africa Grid Science Gateway is a standard-based web 2.0 demonstrative platform to show the lighthouse applications identified by the eI4Africa project and execute them on a worldwide (including Africa) e-Infrastructure5.

The infrastructure that has been developed at KENET and other collaborating NRENs in Africa will be used to access the Africa Science gateway. The ei4africa Research Infrastructures program focused on ICT-based infrastructures and services that cut across a broad range of user disciplines. It aims at empowering researchers with an easy and controlled online access to facilities, resources and collaboration tools, bringing to them the power of ICT for computing, connectivity, storage and instrumentation. This will create virtual research communities.

### **1.6 EUGridPMA Accreditation and Developing ICT staff for research services**

The EUGridPMA is the international organization that coordinates the trust fabric for e-Infrastructure for research in Europe, the Middle-East, and Africa6. It collaborates with the regional peers APGridPMA for the Asia-Pacific and The Americas Grid PMA in the Interoperable Global Trust Federation. KENET is in the process of accreditation by the EUGridPMA. Once accredited, the KENET community will have access to e-infrastructures in Europe.

The successful setup and running of platforms which support research infrastructures require highly skilled staff. The KENET research division comprises of network engineers, system administrators and application developers. The capacity is developed through an ICT development pipeline which sees entry level staff transition to senior positions over time as they acquire more skills. The division focuses on the setup and development of tools to

support researchers on the KENET network. KENET members of staff who work in the research division have undergone trainings and attended conferences in Africa and globally on research infrastructures.

The division's scope of work involves activities such as drafting policy documents, hardware provisioning, software setup, maintenance and connecting with researchers from various institutions on the KENET network. The KENET CA setup under the guidance of EUGridPMA who will give us the accreditation involved writing of a policy document which will guide operations of the Certification Authority and now the setup of the KENET CA as per the policy which is an ongoing project.

## 5. Conclusion

KENET has been at the forefront in the development of appropriate Research Services for the Kenyan Researchers by promoting the use of the shared services and provision of access to advanced e-infrastructures. Even with low budgets, universities and researchers can take advantage of the KENET infrastructure to access various research tools, resources and computing facilities available in grid networks and science gateways availed through KENET. The cost of research resources has also been reduced and collaboration with researchers separated by distance has been made easy.

KENET plans to sensitize the researchers on the availability of research infrastructures at KENET and collaborate with other NRENs in Africa and beyond in improving the available infrastructure. It also aims to build more capacity both at its secretariat and at the research universities and institutions in order to make the use of the infrastructures easier.

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## Biographies

**Peter Muia** joined KENET in 2008. He graduated from the University of Nairobi with a BSC, Computer science. Currently he is pursuing a Masters degree in Computer Science from the same university. He works as a Senior Systems Administrator at KENET. He has been supporting member institutions in setting up and administration of e-learning systems and the setup and administration of e-infrastructures. He is also responsible for systems and network security for the KENET network. Currently, Mr. Muia has been working with a group of researchers in the ei4africa project in setting up of a Certificate Authority and an identity provider for KENET. He is a certified Linux systems Administrator and a certified Cisco Network administrator (CCNA).

**Ronald Osure** is an Applications Developer at KENET and has 3 years of experience in application architecture, design and development methodologies. He has developed solutions to allow the KENET Network Operations Centre leverage on the various Open Source Technologies they use through integrations and customizations. He also works in the research and cybersecurity divisions of KENET. Mr. Osure is a Certified Ethical Hacker (CEH) in cyber security. He did his Bachelors of Science degree from Egerton University (2011) and attended the Summer School of Networking at Indiana University in 2013 which focused on cyber security and Software Defined Networking.

**Prof. Meoli Kashorda** is currently the Executive Director of KENET. He is also a professor of information systems at USIU University in Kenya with research interests in measuring the Institutional ICT readiness in developing countries, telecommunications regulation and broadband Internet as an innovation platform. He previously served as dean of the USIU business school in Nairobi and a telecommunications expert in the Communications Appeals Tribunal of Kenya. He holds a BS degree in Electrical Engineering from University of Nairobi and a PhD in Electronic Systems Engineering from University of Essex in England.