

A Strategy for Developing High-end ICT talent for Emerging African NRENs – The case of KENET

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Abstract

Emerging African National Research and Education build and maintain advanced broadband networks that interconnect universities and research institutes. In order to achieve their mandates, emerging NRENs must attract and retain a critical mass of high-end ICT talent to operate the broadband networks and develop innovative services to the higher education community (Haruta et al 2011). In most cases, the NRENs must rapidly develop a critical mass of networking staff to operate the networks and develop the services in a cost-effective fashion. This paper describes the strategy adopted by the Kenyan research and education network, KENET, to attract, develop and retain the necessary networking professionals that operate the broadband network. The strategy aims to create a pipeline of high-end ICT professionals from a large base of entry-level ICT staff that are recent graduates of electrical engineering, computer science and information systems. This paper concludes that this strategy could be adopted by other African NRENs and higher education institutions to develop the required critical mass of high-end ICT talent.

Keywords: *NRENs, ICT talent development, strategy*

1. Introduction

The Association of African Universities (<http://www.aau.org>) developed guidelines for self-assessment of ICT readiness of African universities in the year 2001 [AAU 2001]. This was also the period when the World Bank through InfoDev (<http://www.infodev.org>) was promoting e-readiness studies in some African countries with one of the indicators being integration of ICT in education (Kashorda et.al. 2007). Many African universities had therefore realized the need to integrate ICT in teaching, learning, research and management in the 2000s and many were achieving success with even very limited International Internet bandwidth (Lindow 2011). In Eastern Africa, e-readiness surveys of 50 East African universities conducted in the year 2008 concluded that the universities valued ICT and had been investing campus ICT infrastructures and Internet connectivity (Kashorda &Waema 2009).

However, progress in the adoption of ICT in teaching and learning had been limited by inadequate investments in campus networks and networked computers for students and faculty, and the relatively high Internet costs. Table 1 shows that the ICT indicator of bandwidth per

1,000 students was 430 kb/s and student PCs per 100 students was 5.3 for universities in the five East African countries in November 2008 (Kashorda & Waema 2009). These ratios had increased to 5.3 Mb/s per 1,000 students for the 17 Kenyan universities included in the study but the PC ratio had only increased from 5.3 to 5.9 by April 2013.

Internet availability indicators (2008) *see change for 2013 Kenya*

Country	Number of Institutions	Total students	Total students PCs	Total Bandwidth (MB/s)	BW per 1000 students	PCs per 100 students
Burundi	5	20,537	308	2.4	0.115	1.5
		162,319	8,544	71	0.436	5.3
Kenya	17	(279,559)	(16,539)	(1,474)	(5.3)	(5.9)
Rwanda	7	32,450	2,367	31.5	0.971	7.3
Tanzania	9	41,816	1,130	17.2	0.412	2.7
Uganda	10	95,550	6,489	29.7	0.311	6.8
Total	48	352,672	18,838	151.6	0.430	5.3



Table 1: Internet Bandwidth and networked PC ratios in Eastern Africa Universities

The high cost of Internet was partly due to the fact that many African countries were connected to the global Internet via expensive satellite links. But analysis showed that high cost of commercial leased lines used to build the national backbone and access networks also increased the total cost of Internet access. In addition, the relatively high salaries of specialized ICT staff required to operate Internet infrastructure also increases the unit cost of Internet bandwidth.

The first undersea cable landed on the East African coast only in July 2009. By the year 2010, three undersea cables had landed on the East African coast (see <http://manypossibilities.net/african-undersea-cables/>). This had the effect of reducing the International Internet bandwidth costs and the available international capacity. Consequently, the unit price of Internet bandwidth dropped from \$3,000 per Mb/s per month in 2008 to \$160 per Mb/s per month in 2012. Universities could therefore afford to purchase higher capacities of Internet bandwidth and the aggregated bandwidth demand increased from only 75 Mb/s in November 2008 to about 2,600 Mb/s by November 2013.

African universities in different African countries started forming associations or organizations to address the issues of affordability and access to global Internet in the late 90s. The Tertiary

Education of Network (TENET) in South Africa and Kenya Education Network (KENET) were early examples of such associations or organizations that were formed in the late 1990s. The primary objects of the organizations was to aggregate demand for Internet for the higher education sector and therefore secure lower Internet bandwidth prices. These organizations have evolved into fully-fledged National research and education networks (NRENs) that operate broadband networks for the higher education community. There were 14 NRENs that were members of the UbuntuNet Alliance by June 2013, five of them had operational networks. An NREN requires networking professionals to build and operate the broadband networks.

This paper describes a strategy adapted by KENET for attracting, developing and retaining the high-end ICT talent required to operate broadband IP network in a highly competitive environment. This strategy could be adopted even by commercial operators with the effect of reducing the total costs of Internet bandwidth in Kenya while also increasing the operational efficiency of broadband IP networks.

The rest of this paper is organized in the following way. Section 2 describes the evolution of KENET from an ICT in higher education organization to a fully-fledged broadband network operator and organization, providing bandwidth and shared services to the connected higher education institutions and research institutes. Section 3 summarizes the ICT talent requirements based on the services provided by KENET. The context of engineering and ICT education in Kenyan universities is summarized in Section 4, highlighting the hands-on training needs for new graduates. Section 5 introduces the strategy developed by KENET to attract, develop and retain ICT talent. The section also highlights ways in which the ICT staff development strategy could be scaled up and replicated by other public and private organizations that provide ICT-based services. Our conclusions are contained in Section 6.

2. Evolution of KENET as an Organization and Network

Kenya Education Network (KENET) was one of the first Academic networks in Sub-Saharan Africa. It was formed as a membership organization by Kenyan universities and research institutes in 1999 with following objectives:

1. **Aggregating Internet bandwidth** demand of the Kenyan higher education sector. This made it possible to negotiate favorable pricing for Internet bandwidth with the commercial incumbent Internet backbone operator (i.e., to increase affordability of Internet).
2. **Promoting the adoption of ICT in higher education sector.** This in turn would increase the demand for ICT services and make it possible for commercial operators to reduce Internet prices. In Kenya, this advocacy role was achieved through e-readiness survey studies of higher education institutions using research grants from the Rockefeller and Ford Foundations.
3. **Attracting ICT infrastructure grants** from the government, foundations and other development agencies.
4. **Promoting collaboration and innovation** among of faculty and researchers in Kenyan higher education and research institutions.

5. **Providing access** to electronic learning resources, research databases and digital libraries available in the global Internet and academic networks.
6. **Capacity development and training** of specialized ICT staff for the higher education sector

The United States Agency for International Development (USAID) had then given the Kenya Government a grant of \$300,000 that was to be used to purchase Internet bandwidth for higher education institutions and research institutes under the Leland Initiative (<http://www.usaid.gov>). This infrastructure grant was finally increased to \$1.1 million in 2001 and was mainly used to upgrade the Internet backbone of the incumbent operator and build six last mile radio links to connect the institutions. The resulting network was owned by the commercial operator. In return, KENET member institutions were connected to the Internet at prices that were 50% the commercial prices. *All the engineering expertise required to operate the academic network was provided by the incumbent commercial operator.* KENET focused on a coordination role and training of ICT staff who operated the higher education campus networks.

However, as early as the year 2000, KENET recognized that it could not provide affordable high-speed connectivity as long it was just a broker for the higher education community without operating a physical network. KENET was granted an operator license at in the year 2002 but did not have the resources to build and operate a private academic network.

In the year 2005, KENET received an infrastructure grant of \$500,000 from the Partnership for Higher Education in Africa (PHEA) to build and operate the first VSAT network that could provide international connectivity. KENET had to develop its own network engineering capacity to operate the network and transition from a coordinating secretariat to a fully-fledged licensed operator.

The biggest challenge is building the network engineering capacity and high-end ICT talent was inability to pay competitive salaries. University interns and young graduate engineers provided the technical services but were not prepared to operate a complex broadband network.

In the year 2008, KENET developed the first sustainability plan as part of requirement for disbursement of a \$19 million grant by Government of Kenya under the Kenya Transparency and Communications Infrastructure project. The plan required that connected member institutions make contributions to pay for recurrent cost of the KENET network, including paying the salaries of the network engineers and other technical staff.

KENET also developed a revised strategic plan for the period 2007-2011 that had a big component of capacity development and sustainability. In the five years between the years 2008-2013, KENET helped the member institutions absorb an infrastructure grant of \$22.5 million under KTCIP. This grant was used to build an national broadband network shown on Figure 1 and to purchase 1200 Mb/s of international 15-year IRU circuits. The KENET broadband had a distribution capacity of about 30 Gb/s and international capacity of 1950 Mb/s serving 134 member institutions' campuses in different parts of Kenya. The network included up to 1,000 KM of KENET-owned lit fiber and about 2.5 Gb/s of leased line capacity.

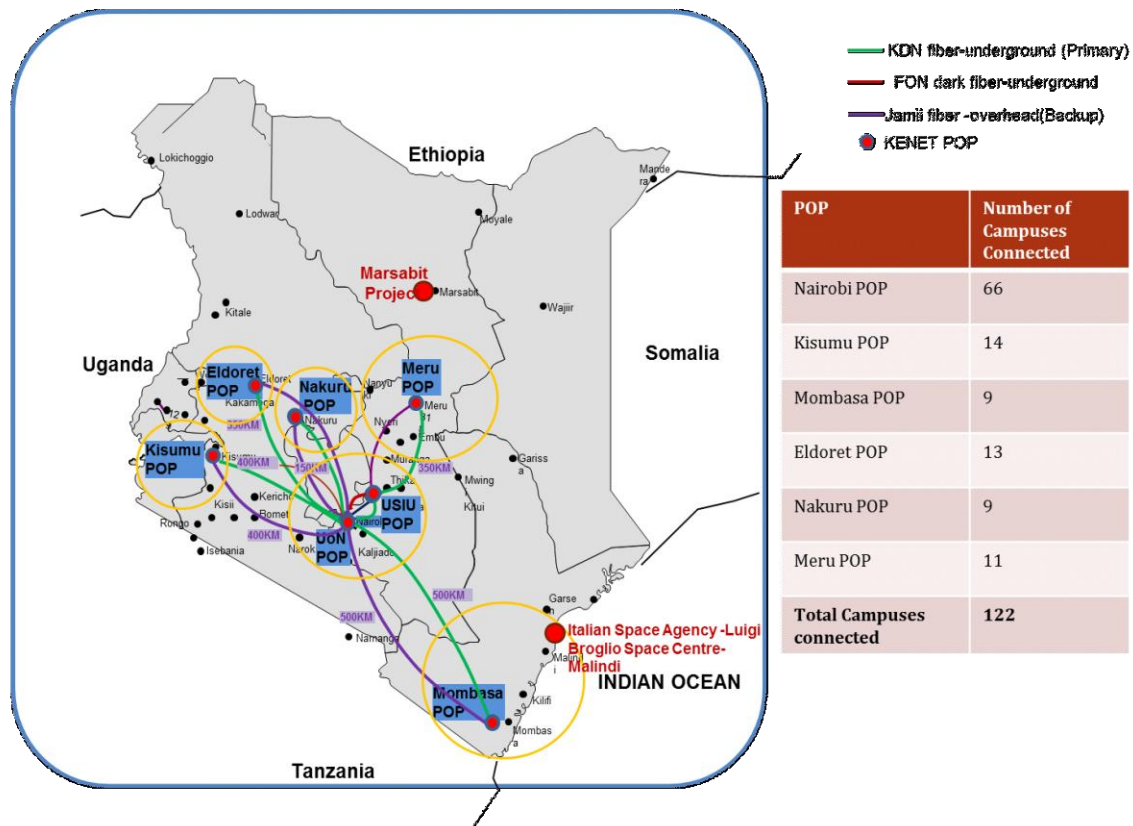


Figure 1: KENET PoP Network

The unit price of bandwidth in that period had dropped from \$3,000 per Mb/s of satellite bandwidth in November 2008 to \$160 per Mb/s in November 2013. This was the lowest broadband price for contention-free bandwidth in Kenya. KENET had therefore achieved one of its key objectives of providing affordable broadband Internet to member institutions.

In order to operate the broadband network, KENET had to develop the necessary network engineering and ICT technical capacity. As of June 2013, KENET had 20 full-time ICT staff members, the majority electrical engineering graduates. About five of the engineers who have been with KENET for four years and above were considered high-end ICT talent, capable of building and operating a large broadband network.

In order to understand the ICT talent requirements, the next section summarizes the main services provided by KENET. Since this paper focuses only on degree-level high-end ICT talent development, Section 4 provides a context for engineering and computing education in Kenyan universities, highlighting the gaps that need to be closed through hands-on and professional training.

3. KENET services and ICT talent requirements

An NREN is often defined as a specialized Internet Services Provider (ISP) that provides mainly broadband network services to the higher education and research community (Dyer 2009).

KENET is more than a specialized ISP and provides the following services:

1. Broadband Internet and network operations (NOC) services. This is similar to any ISP
2. Shared services such as Web hosting, disaster recovery , server co-location, virtual servers and storage services, cybersecurity and research computing services
3. Engineering projects procurement and project management
4. Campus networks design, implementation, and operations services
5. Training services for entry-level and middle-level ICT staff
6. Educational technology and content development services

In the period 2008 – 2013, KENET has been technical capacity to provide the above the services. Table 2 summarizes the services provided by KENET and the categories of ICT professionals required and the basic university degrees required by each category.

Service	Service provider institution	Engineering and ICT skills required	Relevant undergraduate degree
Broadband Internet service, and NOC services	KENET (NREN)	Network engineering, Network Administration Programming and applications development	Electrical Engineering (EE), Computer Science (CS) and Information Systems (IS)
Shared services	KENET / HE institutions	Network engineering, Systems administration Network administration Programming skills Database administration	EE, CS, IS
Campus Networks Services	HE institutions / KENET	Network engineering Network administration Wireless Network Design and Operations Bandwidth management Systems Administration	EE, CS, IS
Procurement Project management services	HE institutions / KENET	Electrical and Power Engineering Technical communication skills Consulting skills Preparation of Technical Bidding (tender documents) Negotiation skills	EE + MBA or MIS CS + MBA or MIS IS + MBA or MIS
Training services	HE institutions / KENET	Training skills; technical skills in systems and	EE, CS, IS

		network administration, cybersecurity skills	
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Key: CS – Computer Science; EE- Electrical Engineering or equivalent; IS – Information Systems or equivalent; MBA – Master of Business Administration; MIS – Master of Information Systems or equivalent

Table 2: Services and ICT skills required

We note that some of the services could also be provided by the higher education institutions or by commercial ISPs. However, one of the competitive advantages of KENET when compared to the commercial ISPs is the close working relationship and trust between KENET ICT staff and the ICT staff of higher education institutions. This has only been possible because of the critical mass of high-end ICT talent available to solve the problems of the higher education institutions. This is consistent with recent research findings on the future of NRENs in Europe [TERENA 2012]

Since KENET ICT talent development strategy depends on availability of quality engineering and ICT graduates, the next section provides a context for engineering and computing education in Kenya. We note that in Kenya as in most other African countries there is a general criticism that university engineering and computing education does not meet the needs of the ICT industry. The KENET ICT talent development strategy therefore aims to close any gaps in university education.

4. Context of Electrical Engineering and Computing Education in Kenya

1.1 Electrical and computer engineering education

The University of Nairobi has oldest Engineering degree programs having started in 1971. However, engineering education in East Africa had started in 1956 originally as part of the Royal College of Engineering and later as part of the University of East Africa. As of September 2012, six public universities in Kenya were offering electrical engineering degree programs (Kashorda 2012)

Engineering education in Kenya is regulated by the Engineers Act 2011 that came into effect on September 14, 2012. The Engineers Act 2011 enhanced the powers of the Engineers Registration Board to include approval and accreditation of engineering degree programs in public and private universities or other tertiary institutions like university colleges (see <http://www.kenyalaw.org>). This new law is supposed to enhance the quality of engineering education in Kenya using an accreditation process. The Universities Act 2012 also makes it mandatory for universities to obtain institutional accreditation from the Commission for University Education (see <http://tahest.kenet.or.ke>). Thus, it is expected that quality of engineering education will continue to improve in the future.

However, the annual enrolment in engineering degree programs has increased dramatically over the years without any significant increase in laboratory or classroom facilities. For example, University of Nairobi, Jomo Kenyatta University of Agriculture and Technology and Moi University admitted 2,300, government sponsored students. Although electrical engineering

degree programs admit some of the top high school students in Kenya, the lack of facilities and high student to faculty ratios had a negative impact on quality of graduates in the 2000s according to a study by IBM Corporate Social Corps consultants in 2011 (Haruta et.al. 2011). The main weakness was identified as the lack of hands-on experience obtained through laboratory exercises and student projects. Moreover, the curriculum at the leading universities had not been regularly reviewed to introduce, for example, courses in IP network engineering and general education subjects like communications. The lack of structured internship and graduate training programs by local industry had also reduced the pool of well-trained engineering graduates. It is these weaknesses that the KENET capacity development program aims to address.

1.2 Computer Science and Information Systems Education

All of the 21 public universities and 14 chartered private universities offer computer science, information systems or IT degree programs. The information systems degree programs have technical and business components and prepare graduates who develop, deploy and administer organizational information systems and networks. These graduates are in high demand because of the increasing deployment of information systems in many large and medium-sized enterprises in East Africa.

However, the ICT industry continued to complain that the graduates were not well prepared for most of the large ICT projects. For example, banks had to import the high-end ICT talent from India or Europe for project implementation at very high cost (Haruta et.al. 2011).

Note that unlike engineering degree programs, computer science and information systems degree programs in Kenya are not regulated by specialized regulatory body. Only the Commission for University regulates the degree programs indirectly through the accreditation process. That means that the learning outcomes are varied and it is the employers who have to determine the quality of the degree. However, the top 10% of the graduates of the local universities had excellent aptitude and aptitude and could be converted to high-end ICT talent in a period of three or four years.

1.3 Strengthening engineering and computing education in Kenya

The long-term solution to improving the quality of ICT graduates, including electrical engineering graduates, includes the following:

1. Regular curriculum review (e.g., every three years for ICT degree programs)
2. Increasing investments in laboratory facilities for electrical engineering and ICT degree programs
3. Investing in capacity development for ICT faculty, including industry attachments, research funding, and doctoral scholarships
4. Strengthening university-industry linkages.

All of the above recommendations have been summarized in the Government of Kenya Sessional Paper 14 on education policy (Government of Kenya 2012). However, ICT industry in Kenya

(and in the rest of Sub-Saharan) must adopt short-term and medium-term innovative programs for developing high-end ICT talent required to operate complex networks and information systems. This is especially critical in the higher education sector that does not have the resources and revenues of commercial companies like banks and mobile operators to attract talent using high salaries.

Section 5 describes an ICT talent development program that KENET has been implementing in the past five years and the results achieved. This program can be scaled up to increase the pool of ICT talent. It is also a cost-effective talent development program that can be adopted by other ICT companies and organizations.

5. ICT Talent Development Strategy

5.1 ICT talent development pipeline

In the year 2007, KENET had only two degree-level technical staff members that were operating the VSAT network serving about eight campuses and distributing about 12 Mb/s of satellite bandwidth. As of June 2013, KENET had 20 technical staff members with only five of them having been with KENET for five years and above.

In the year 2011, KENET formally adopted ICT talent development pipeline as shown in Figure 2

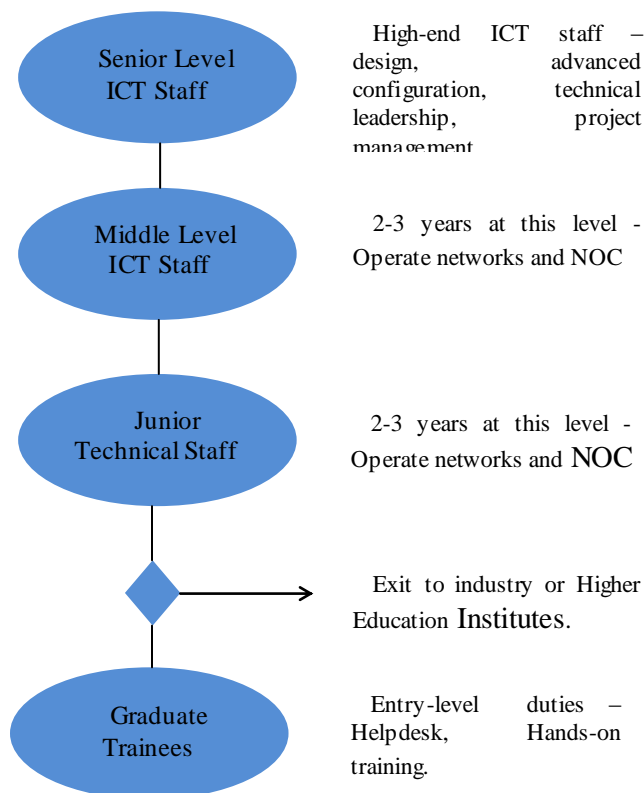


Figure 2: KENET ICT Talent development pipeline

In the period 2008-2011, KENET recruited ICT staff at the junior, middle-level and even senior level. This was often necessary in order to attract experienced engineering especially for network development and operations. However, in the year 2012, KENET introduced the graduate trainee program that provides for one-year training for graduates before they were recruited into full-time positions in KENET.

The ICT talent development pipeline does not capture the fact that KENET has an active Internship program for undergraduate university students, mainly in their third to fifth year of degree study. The internship program had been used to attract the top 10% graduates from Kenyan engineering and computing degree programs.

5.2 ICT staff training and promotion

The strategy aims to create a pipeline of ICT professionals from a large base of entry-level and junior level ICT staff that are recent graduates of electrical engineering, computer science and information systems. Only a fraction of the entry-level trainees are absorbed as middle-level ICT staff, with the rest expected to join the local ICT industry after one-year of intensive hands-on training in networking and systems administration.

The entry-level graduate trainees receive hands-on training in network administration and systems administration. In many cases, this would be their first hands-on experience working with servers and network equipment. In addition, they are trained to provide NOC helpdesk services under supervision. They also visit member institution campuses and learn about campus network design and operations. At the end of nine months, the trainees are evaluated by senior ICT staff in different areas including attitude and skills acquired. The successful trainees join KENET as junior ICT staff as full-time employees while the rest exit to the local ICT sector.

The junior technical staff members are required to specialize in one of three main areas:

1. Systems administration
2. Network administration
3. Network engineering

They continue to work under supervision of the middle-level and senior technical staff and are assigned increasingly complex projects. They attend boot-camp training offered by KENET, AfNOG, NSRC, UbuntuNet Alliance and network equipment vendors (e.g., EMC for storage, CISCO for networking). After about two years at junior level, they are then eligible for promotion to middle-level positions. Promotion is based on at least two annual reviews of performance by supervisors.

The middle-level staff members continue to participate in advanced hands-on training under the mentorship of senior ICT staff. It is middle-level and senior level ICT staff members who

participate in twinning programs with developed country NRENs or attend advanced level training in different areas of network operations. In the period 2009-2013, four engineers had visited DFN in Germany and two DFN engineers had visited KENET in Kenya. This had enhanced the technical capacity of KENET to provide advanced services, including specialized procurement of network equipment.

Middle-level staff members are eligible for promotion to senior ICT staff levels after two or three years based on availability of senior positions. The KENET strategy prefers internal promotions to senior technical levels except in cases where some critical skills and capacity were lacking at the middle-level.

The senior ICT staff members provide technical and business leadership necessary for effective operation and growth of KENET. It is this team that develops new services and policies for NOC operations and member institutions. They also serve as the overall project managers in large network projects and are responsible for network planning and design and procurement. Training at this level is through practical projects execution, attending international conferences and participating in twinning programs.

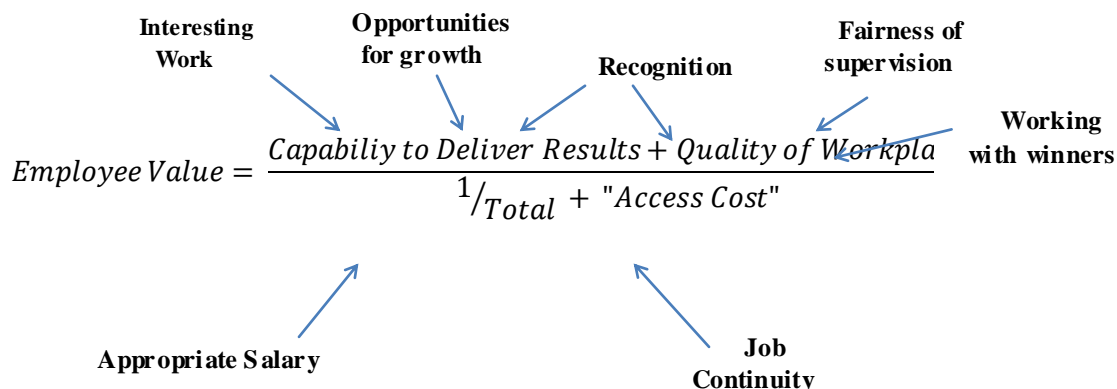
We note that in the initial stages of development of KENET has recruited mainly graduates with electrical engineering degrees. This is because of heavy emphasis on infrastructure development, including electrical works. In the future, there shall be increased demand for information systems and computer science graduates that will be systems administrators and applications developers. In the next sub-section, we describe some of the retention strategies adopted by KENET.

5.3 ICT staff retention strategies

The shortage of high-end ICT talent in Kenya (and other sub-Saharan countries) means that retention of ICT staff requires innovative solutions. The private ICT sector in Kenyan in general responds by increasing the salaries of ICT staff. This is not sustainable for KENET or the higher education institutions.

In Kenya, the consulting firm PWC publishes salary surveys for ICT staff every two years in different economic sectors. KENET has determined that it falls in the Small and Medium-Sized Enterprises (SME) based on revenues. Unfortunately, KENET competes with the large mobile operators and Internet Service providers in terms of Internet traffic and size of the IP network and the shared services provided to the higher education institutions. This is a challenge for all NRENs globally. For example, Internet2 in the US has introduced NET+ services in partnership with the large commercial ICT companies to avoid the competition (see <http://www.internet.edu>). However, this is not an option in a developing country like Kenya where the ICT sector is not yet fully developed and lack the necessary high-end ICT talent to deploy and support the advanced services.

The KENET ICT talent retention strategy can be explained using the employee value equation (Heskett et.al. 2003). The value equation is expressed as follows:



The equation shows that there are many variables that could be manipulated to increase the value of KENET to its employees. Staff retention increases with increasing perception of employee value. Notice that an appropriate salary is just one of the variables. The other variables include interesting work, opportunities for growth and the quality of the workplace.

Although KENET pays competitive for the SME sector, it focuses on the variables capability to deliver results and improving the quality of the workplace in the value equation. Each technical staff members is given challenging projects and work assignments, is continuously being trained and has opportunities for promotion and growth. The quality of the workplace has improved through hiring very talented young engineers with positive work attitudes (i.e., working with winners). The fact that KENET had many network expansion projects in the period 2008-2013 and was governed by credible Trustees means that it was perceived as a stable and sustainable organization by both KENET staff and member organizations.

KENET has therefore deliberately chosen to emphasize the non-salary variables of the employee value equation while still paying competitive salaries according to the PWC salary survey studies.

6. Conclusions

The first African NREN-like associations or organizations were formed in the late 1990s mainly to aggregate the demand for Internet bandwidth of higher education institutions. Some of these organizations transitioned to fully-fledged NRENs in the 2000s operating broadband networks and providing affordable broadband services. Such operational NRENs, that include KENET, operate in direct competition with commercial ISPs and operators not only for the business of providing Internet services but also for high-end ICT talent.

This paper has described the ICT staff development strategy adopted by one African NREN, KENET. KENET evolved into a fully-fledged operator offering bandwidth and shared services and with a technical ICT staff complement of 20. The technical staff members operate a complex national broadband network as also providing specialized ICT consulting and diagnostic services to over 130 connected campuses.

The ICT capacity development strategy creates a pipeline of technical staff consisting of graduate trainees, junior technical staff, middle-level technical staff and the senior technical staff considered the ICT high-end talent. The junior and middle-level technical staff operate KENET broadband network and shared services. The senior technical staff members provide technical and business leadership as well as projects management.

The retention growth of both the middle-level and senior-level categories of employees is critical for sustainability of KENET. The retention strategy for ICT staff focuses on non-salary variables of the value employee value equation described in Section 5. The employee value equation shows that the quality of the workplace and opportunities for growth are important for staff retention. However, KENET has also confronted the challenge of staff retention by paying competitive industry salaries comparable to those of SMEs in the ICT sector.

The author believes that this ICT staff development strategy can be replicated in the large higher education institutions, private organizations, and the government. This would in turn build a large pool of ICT talent required for execution of large ICT and network projects in Kenya and in the region. The author believes that a variation of this strategy could also work in other sub-Saharan countries.

The paper concludes that if this strategy were adopted by the ICT industry in African countries, it would be possible to develop the required high-end ICT talent, thus making it possible for NRENs to compete with commercial mobile and Internet service providers.

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Biography



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