Strategies for Connectivity Configuration to Access e-Learning Resources: Case of Rural Secondary Schools in Tanzania

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***Abstract*—**In response to address different development challenges, Tanzania is striving to achieve its fourth attribute of the National Development Vision, i.e. to have a well educated and learned society by the year 2025. One of the most cost effective methods that can reach a large part of the society in a short time is to integrate ICT in education through e-learning initiatives. However, e-learning initiatives are challenged by limited or lack of connectivity to majority of secondary schools, especially those in rural and remote areas. This paper has explores the possibility for rural secondary school to access online e-Learning resources from a centralized e-Learning Management System (e-LMS). The scope of this paper is limited to schools that have computers irrespective of internet connectivity, resulting in two categories schools; those with internet access and those without. Different connectivity configurations have been proposed according to the ICT infrastructure status of the respective schools. However, majority of rural secondary schools in Tanzania have neither computers nor internet connection. Therefore this is a challenge to be addressed for the disadvantaged schools to benefit from e-Learning initiatives.

***Keywords*—**connectivity, configuration, e-Learning, replication, rural.

I. INTRODUCTION

TANZANIA has a national development vision – Vision 2025 that lists five attributes achievable by the year 2025; namely (1) High quality livelihood (2) Peace, stability and unity (3) Good governance (4) A well educated and learning society (5) A competitive economy capable of producing sustainable growth and shared benefits. However, the current teaching-learning process in Tanzania is mostly teacher-led; based on "chalk and talk" methods. It happens in an environment with insufficient teachers, teaching-learning resources, and suitable textbooks [1]. The "chalk and talk" method assumes that learning is merely listening (i.e. teacher centered and know it all), which in turn denies students the chance to actively participate in the learning process. This method uses a small part of the learning pyramid; hence it hampers the rate of retention and therefore limits the degree of achieving the desired objectives of imparting quality education. These shortcomings are to be addressed if Tanzania is to achieve its fourth attribute of the Vision 2025.

It is envisioned that the use Information and Communication Technologies (ICT) in education can improve teaching/learning processes [2,3]. One way to incorporate ICT in education is through e-Learning. The e-Learning includes a wide variety of learning strategies and technologies, from Compact Disk- Read Only Memory (CD-ROMs) and computer-based instruction to videoconferencing, satellite-delivered learning and virtual educational networks [4]. In contrast to traditional forms of teaching/learning that require participation in specific courses at specific times and locations, e-Learning can take place anytime and anywhere and from any source. E-learning separates the teacher and the student in space and/or time, making the student in-charge of the process.

The government of Tanzania through its ministry of education promoted computer literacy in ICT by issuing a syllabus of computer studies for secondary schools in 2000, which was revised in 2002. In 2007, the government took further steps of developing an ICT policy to guide integration of ICT in basic Education [5]. The strategic integration of ICT in education is expected to improve access, equity, quality and relevance in all levels of basic education [5]. Therefore ICT is taken as an enabling tool to achieve the fourth attribute of the development vision 2025. In addition to the government efforts, there are other non-governmental initiatives such as the introduction of websites with learning materials for secondary schools e.g. http://www.tanedu.com. The learning materials in these websites can only be accessed online. Therefore, schools with no internet connection cannot access such online learning resources. It has further been observed that there are other few e-learning initiatives in Tanzania however they do not facilitate self-learning. In addition to that principal weaknesse; they are also urban-biased. Therefore, rural and remote schools are still the disadvantaged group even with the availability of online e-Learning resources.

Another non-governmental initiative is the ICT for Rural Development project under College of Engineering and Technology (CoET) in the University of Dar s Salaam (UDSM). The project aims at developing e-Learning system for rural secondary schools in Tanzania. The project has three components, as shown in figure 1. The projects components'

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have been tailored in order to address shortcomings/weaknesses of the existing e-Learning initiatives. In 2004, the project conducted a survey in 40 secondary

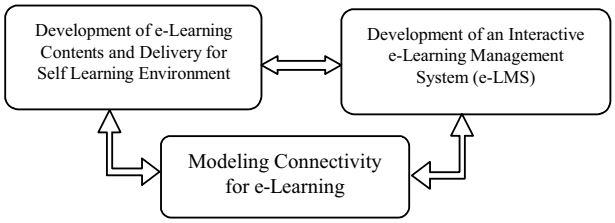


Fig. 1 The e-Learning Project Components

schools from 12 districts in Tanzania. The aim of the survey was to find out what is the status of ICT infrastructures in secondary schools (referred to as "e-readiness"). The survey results are summarized in Table 1.

Survey results shown in Table 1 suggest a poor e-readiness for the surveyed schools, although this can reflect the general picture or even worse for most secondary schools. This is due to the fact that most of the surveyed schools have very few computers and computer literacy personnel, in a range of 1-5.

TABLE I
SUMMARY OF SURVEY RESULTS IN REGARD TO AVAILABILITY OF ICT INFRASTRUCTURES

S/N	ICT infrastructures	Number of Schools
1.	Availability of Telephone infrastructure	9
2.	Availability of Electricity	36
3.	Availability of Computers	
	0 – 5	21
	6 – 10	3
	11 – 20	6
	21 – 30	6
	31 - 35	4
	36 - 40	0
4.	Schools with internet connectivity	4
5.	Number of Computer Literacy	
	0 - 5	33
	6 - 10	6
	11 - 20	1
	21 - 25	0

There are only four (4) schools with internet connectivity among the surveyed 40 schools. However , Kibaha and Waliul Asr secondary schools, both from Coast region were selected to serve as pilot schools in this project from a criterion of easy accessibility by road. It is important to note that student population for such schools is between 400 and 2,000.

A. Challenges for Rural Connectivity in Tanzania

Referring to the survey results in Table 1, it is shown that the most of the rural schools have shortage or total lack of ICT infrastructures like computers, ICT literacy personnel, telephone infrastructures and source of electrical power. These are challenges to establish connectivity to the rural areas since the missing infrastructures are the prerequisite for connectivity establishment. Another challenge is the high cost to maintain last-mile connectivity in rural areas. Last-mile connectivity is the last piece of connection from a nearby point of access to the end users' machine. Usually a customer is responsible to pay the cost of establishing and maintain this piece of connection in order to access Internet based services. Cost of last mile connectivity consists of initial installation cost, monthly charges and terminal equipment costs. However, the cost widely varies depending on the amount of bandwidth and different types of connectivity technologies.

The high cost of connectivity is primarily attributed to the fact that most of Network Facilities and Service Providers (NFSPs), formerly known as Internet Service Providers (ISPs) are based in urban localities and their services likewise. This situation creates a costing structure where prices become relatively higher for rural end users [6] which is opposite of income profiles. A mismatch between the type of service requested and the service offered is also another factor that contribute to the high cost of connectivity. Most of ISPs have fixed charging system that does not take into consideration different type of access needed. For example, if a videoconference session with only participants within the country needs 512kbps of bandwidth, the NFSP will charge for 512kbps link to the internet which is expensive [6]. However, if the NFSPs were to offer 512kbps local link with no access to the internet, the cost would be relatively lower. This mismatch between service provided and service required is due to the ICT illiteracy of end users. The few trained IT personnel are concentrated in cities since the supply is short and the demand is high. It is obvious that the e-Learning resources will not be accessible to the rural schools due to poor or total lack of ICT infrastructures, especially lack of connectivity. To address this challenge, appropriate resource sharing models based on existing infrastructures and projected demand is worth trying [7,8].

B. Technology Options for Rural Connectivity

It has been pointed out that an IP based network is a cost effective solution for communicating in non-urban and lowly populated areas [9]. Wireless networks, comprising of mobile/cellular, Wi-Fi, Wimax and satellite (VSAT) have been identified to be technologies of choice for increasing access to phone and Internet services in developing countries. They are not only cheaper, easier and faster to deploy than traditional landline alternatives, but also make possible business and service delivery models better adapted to rural, low income communities [10, 11].

Cellular phone networks, which is a mobile, wireless networks are expanding rapidly and provide some rural coverage. Where there is access it is time and location dependent. They can be used for voice communication but inappropriate for data because they lack or have no or very limited capacity for that. However, there are newer network technologies such as Code Division Multiple Access (CDMA), General Packet Radio Service (GPRS) and High Speed Downlink Packet Access (HSDPA) which have increased data capacity and carriers; they are deployed in higher capacity

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networks like 2.5G, 2.75G and 3G in developing countries. Practical experiences in Tanzania are provided by Vodacom (T) Ltd through its HSDPA mobile services, TTCL mobile through its CDMA2000 network and Celtel Access through its GPRS network [6]. Generally, cellular systems are relatively expensive solutions for data communication [12].

On the other hand there are fixed wireless technologies; the Wi-Fi also known as IEEE 802.11 and the WiMAX, known as IEEE 802.16. The Wi-Fi has been proposed as a cost-effective option to provide wireless broadband in rural areas. In the developing and developed world alike, 802.11 links can be used in long-distance up to 30kms, rural settings. Some examples are: (a) the Ashwini project in Andhra Pradesh, India, (b) the Akshaya deployment in Kerala, India, (c) the Digital Gangetic Plains testbed in Uttar Pradesh, India, (d) DjurslandS.Net: a deployment in Denmark [13]. WiMAX technology relates to Wi-Fi technology but operates at much longer distances and has much higher data capacity than cellular networks. WiMAX networks currently extend the reach of optical fiber backbones by up to 40 kilometers per hop (point-to-point) or distribute service to individual communities at distances of 5-10 kilometers (point-to-multipoint). The technology can provide Internet connectivity to reach the rural community, especially the hub of a community network [12]. Another option, especially for more remote communities, is a generation of satellite networks; VSAT that are designed for data transmission. The VSATs have higher data transmission capacity [6,12]. A practical example is the Tanzanian government initiative which provided broadband internet connectivity to all 32 government owned teachers training colleges [14]. However research and experiences show that implementing the explained connectivity technologies in the Tanzania's rural environment is challenged by limited ICT infrastructures and the high cost of bandwidth [15].

II. Connectivity Configuration Strategies to Access E-Learning Resources

The heart of this paper is on the connectivity component of the ICT for Rural Development Projects, aimed at developing an e-Learning system for secondary schools. The proposed e-Learning Management System (e-LMS) to be developed is web-based three-tier architecture. Figure 2 shows a block diagram of the proposed e-LMS [16]. Kalinga et al., 2007 [16] proposed that the e-Learning's database and application servers will be centrally located at COET –UDSM for easy administration, updating and maintenance purposes. The e-LMS resources will be accessed online by its users who are basically secondary schools that are geographically dispersed within the country. It is further explained that the centralized servers can be replicated to the local servers in schools so as to address any drawbacks of online access like poor performance due to high load or disconnection due to server downtime.

With this setup, then a task is to configure a connectivity solution that will suit the proposed e-LMS setup in order for rural secondary schools to access its resources. Configuration can be defined as a way a system is set up, or the assortment of components that make up the system. Configuration can refer to either hardware or software, or the combination of both (http://www.webopedia.com/TERM/C/configuration.html.

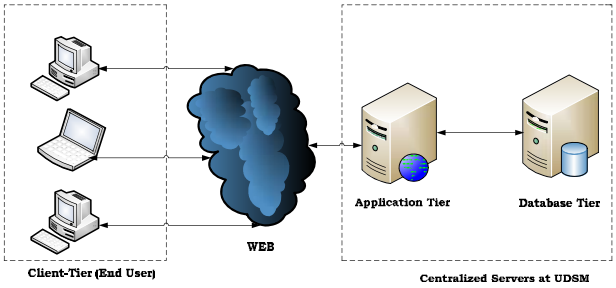


Fig. 2 The e-LMS Three Tier Architecture [16]

accessed on 23 Feb, 2009). The survey results in Table 1, suggest grouping the secondary schools into two categories: schools with and schools without internet connectivity.

A. Connectivity Configuration in Schools with Internet Connection

Schools with internet connection can access the e-LMS resources online through their web browsers. User side system requirements for the proposed e-LMS, are either a personal computer or a laptop machine with a web browser. The client machine must be connected to the internet to access the server, otherwise it cannot be serviced. However, online access has its drawbacks as pointed out by Yair et al., (2002) [17]; poor performance due to high server load or communication latency and availability problems due to server downtime or lack of connectivity. To address the online access drawback, Replication is configured as an alternative solution, where the exact configurations and contents of the central servers are copied to local servers. Teachers/students will access e-LMS resources from their local serves. Figure 3 illustrates online access or of the replicated e-LMS in local server. Replication enables data from one MySQL database server (called the master) to be copied to one or more MySQL database servers (slaves). Replication is asynchronous – the slaves do not need to be connected permanently to receive updates from the master, which means that updates can occur over long-distance connections and even temporary solutions such as a dial-up connection can facilitate replication. Depending on the configuration, you can replicate all databases, selected databases, or even selected tables within a database.

To achieve the above setup, schools are assumed to have Local Area Network (LAN) based on client-server architecture. The LAN's server will serve as local server where e-LMS resources from central server will be replicated to. Student will use the client computers through their web browsers to access the replicated e-LMS resources from local servers. All updates will be done at the central servers while the local servers will be updated through replication [16].

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B. Connectivity Configuration in Schools without Internet Connection

Survey results shows that there are schools with computers

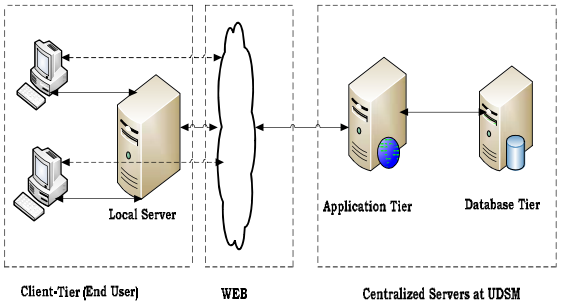


Fig. 3 Online access from central servers or accessing from local server the replicated e-LMS

but they don't have internet connection. These schools cannot access the online e-LMS resources. An alternative solution is to physically deliver the e-LMS contents using removable storage devices like CD-ROMs/DVDs, memory sticks/flash disks or mobile hard disks to the school's local Servers (LAN servers). In this case, it is assumed that the schools have a LAN in the client-server architecture. Therefore, students/teachers can access the e-LMS contents from their

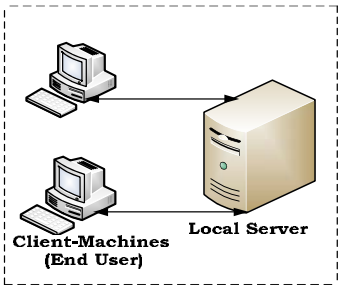


Fig. 4 Accessing from local servers the physically delivered e-LMS contents

local servers through their web browsers as shown in figure 4. The local servers will have exact configuration as that of the central servers, only materials will be brought by using removable storages devices. All updates will be done at the central servers while the local servers will be updated through the use of removable storages devices by physically visiting the sites (schools).Thanks to the selection of pilot schools that are easily accessible by roads.

1) Clustering of the Rural Schools for cost-effective and cost sharing connectivity

Since majority of secondary schools in Tanzania do not have connectivity to the Internet, it is obvious that the only solution for them to access e-LMS resources is through a physical delivery to their premises, assuming that they have computers and client-server LAN architecture for easy access. It is impractical and almost impossible to physically deliver the e-LMS contents to all schools that have no internet connection. The situation is even worse when it comes to deliver the updates, since they will never reach the intended destination within the acceptable delay timeframe. In some cases it can even be worthless, like if the materials were to be updated before exams, but they were not until end of exams due to remoteness or inaccessibility of the area. An envisioned solution is to create centers (schools to host local servers) that can form a group with its nearby schools, i.e forming a cluster of nearby schools. The group's local server will be called cluster server and the nearby schools are not supposed to have servers, they will be clients accessing e-LMS from the cluster server. It is relative practical to updates some few centers (cluster servers) that provide access to a large number of nearby schools. However, in the real situation, these schools do not have any connectivity among themselves. Therefore, a challenge is how will the nearby schools access the cluster servers? To address this challenge, there must be a negotiation with NFSPs to create a customer-tailored connectivity solution that has a local traffic costing structure, since the schools are not accessing the internet. For example, establish wireless

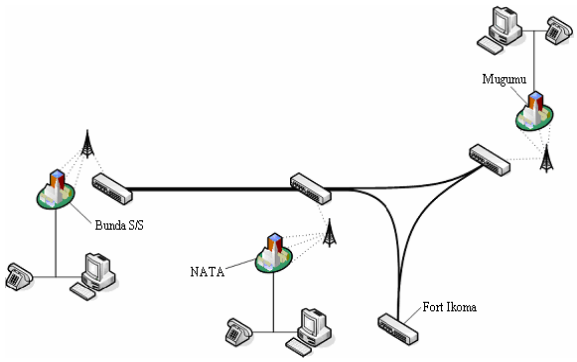


Fig. 5 Logical network diagram of Bunda to Mugumu connection [18]

connectivity that is charged for local traffic only to link each school with the cluster server. This is in line with Chebrulu et al., (2006) [13], who proposed Wi-Fi as a cost-effective technology to provide wireless broadband in rural areas.

Not only wireless but even fiber optic cables can be used for school's connectivity in forming a cluster. The fiber optic cables are used by some companies and ministries in Tanzania for their administrative purposes. If the fiber cable is passing along nearby schools, it can be terminated to the schools to create their local cloud (a cluster). A practical example has already shown by ICT for Rural Development (ICT4RD) project that succeeded to provide ICT access opportunity between Bunda and Mugumu (figure 5) through an optic fiber cable installed by the Tanzanian Electric Supply Company (TANESCO). The fiber is installed in the ground wire known as optical power ground wire (OPGW) along the 33 kV power line primarily for supervision, control and data acquisition (SCADA) along their power grid. The Bunda town, Manyamanyama, Nata and Mugumu town sites are already connected via a 1GB backbone as shown in figure 5.

Another ICT access opportunity is between Wami and Chalinze provided through an optic fiber owned and operated

by Ministry of Water (MoW) for water flow monitoring and accounting systems. This fiber is about 80km long, passing through 18 villages and was terminated at 11 points in different locations at the water monitoring stations. Refer to

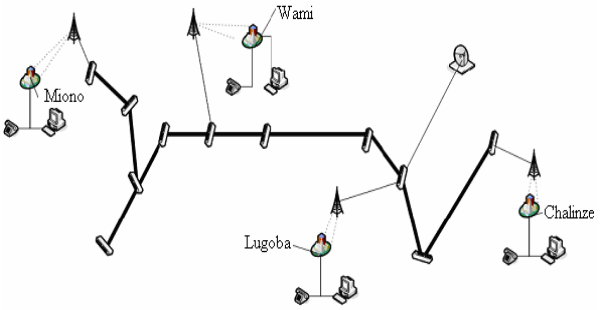


Fig. 6 Logical network diagram, with Miono, Wami, Lugoba and Chalinze connected [18]

figure 6. Likewise, the schools can be interconnected by using the available ICT resources with a local costing structures to form a cluster (local cloud), as shown in figure 7. The clustering setup has a potential to upgrade for online access if the cluster members can share the only cost of broadband internet connectivity to the cluster server. Thereafter a cluster

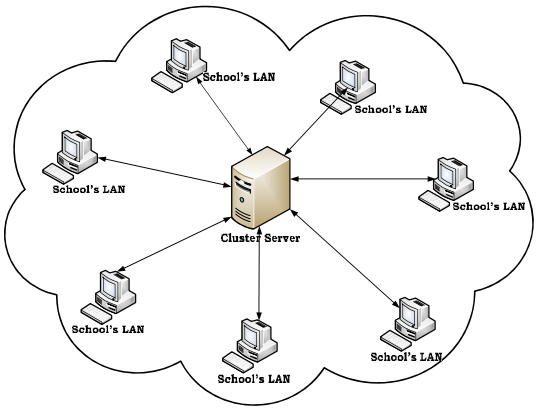


Fig. 7 A cluster of nearby schools accessing e-LMS contents from the cluster server

server will be updated through replication and the cluster server can be used as a hub for other schools (cluster members) to have online access to the central servers.

III. Conclusion

This paper presented connectivity configuration with the assumption that the targeted schools have computers and client-server LAN architecture. But this is not the case in most of the rural secondary schools in Tanzania; they usually have neither computers nor internet access. Some have very few PCs that are also mainly used for administrative purposes [19]. Furthermore, the presented connectivity configuration shows a potential of connectivity cost-reduction due to the use of clustering approach, which is a cost sharing model. The presented configuration can serve as a viable solution to the few schools that have got the assumed ICT infrastructures. However, a large number of schools cannot access the online e-Learning resources unless connectivity and ICT infrastructure challenges are solved.

There is a hope that these challenges will soon be addressed, since the Government of Tanzania through its ministry of education's 'eSchools programme' under formulation. The programme aims at equipping a number of Tanzanian secondary schools with broadband connectivity and ICT facilities for a better and more efficient education system [14]. There are other initiatives under investigation to enable schools without computers or internet connection to access the online e-Learning resources say through mobile phones and mobile network infrastructures.

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References

[1] MoEC. (2002). Education Projects and Programmes. Ministry of Education and Culture. Dar es Salaam.
[2] ICT Policy, (2003). National ICT Policy of Tanzania, Final Draft. http://www.tanzania.go.tz/ictpolicy.doc, Retrieved on 10th Oct, 2007
[3] Mason, R and Rennie, F. (2004). Broadband: A Solution for Rural e-Learning? International Review of Research in Open and Distance Learning, Scotland. http://www.irrodl.org/index.php/irrodl/article/view/173/255. Retrieved on 18th feb, 2007.
[4] Talavera, N., Alvarez, E., Mondelo, P. and Terres, F. (2001). Capturing Requirements for E-Learning Systems Design. In Proceedings of International Conference on Computer-Aided Ergonomics and Safety. Hawaii-USA.
[5] ICT4E, 2007. MoEVT ICT Policy for Basic Education http://www.moe.go.tz/pdf/MoEVT ICT Policy for Basic Education. Retrieved on 3rd June, 2007.
[6] Sheriff, S (2007). Rural connectivity in Tanzania: Options and Challenges. SWOPnet/IICD study report. Dar es Salaam, Tanzania.
[7] Menda, A. (2006). Tanzania: ICT education project amid rural connectivity challenges.www.iconnect-online.org. Retrieved on 28th Feb, 2008.
[8] Isamuyo, Z., (2006). Open Access ICT Infrastructure in Rural Tanzania. Master's Thesis, Royal Institute of Technology (KTH), Stockholm, Sweden.
[9] Chitamu, P. J. and Vaunucci, D. E. (2002), "Networking Africa: A case for VolP, In Proceedings of IEEE Africon, IEEE Catalog No. 02CH37385, George South Africa, pp. 361-366.
[10] Islam, A. H. M. R., Shafik, R. A., Hassan, M. I. and Song, J. B. (2006). Next Generation Rural Wireless Connectivity Model for Developing Countries. In Proceedings of 12th IEEE Asia Pacific Conference on Communications (APCC2006), Busan, Korea.
[11] Raman, B and Chebrolu, K. (2007). Experiences in Using WiFi for Rural Internet in India. IEEE Communications Magazine. pp 104 – 110.
[12] Hammond, A. and Paul, J. (2006). A new model for rural connectivity. Washington, DC: World Resources Institute. http://www.nextbillion/net/files/A_New_Model_for_Rural_Connectivity.pdf, Retrieved on 23rd Oct, 2007.
[13] Chebrolu, K; Raman, B and Sen, S. (2006) ``Long-Distance 802.11b Links:Performance Measurements and Experience". In Proceedings of 12th Annual International Conference on Mobile Computing and Networking (MOBICOM), Los Angeles, USA.
[14] Hare, H. (2007). Survey of ICT and Education in Africa: Tanzania Country Report. www.infodev.org/tanzania-2

International Science Index, Educational and Pedagogical Sciences Vol:3, No:6, 2009 waset.org/Publication/8011

[15] Anatory, J.; Mvungi, N.H.; Kissaka, M.M. (2004). Trends in telecommunication services provision: Powerline network can provide alternative for access in developing countries. In Proceedings of the 7th AFRICON Conference in Africa, Vol.1, pp 601 – 606.
[16] Kalinga, E. A., Bagile, B. R. B., Trojer, L., (2007). "An Interactive e-Learning Management system (e-LMS): A Solution to Tanzania Secondary Schools' Education". International Conference on Computers, Electrical, Systems Science and Engineering (CESSE), 2007 WASET.ORG, ISBN 978-975-01752-0-6, V-21, 19.
[17] Yair, A., Danilov, C., Miskin-Amir, M., Staton, J., Tutu. C., (2002). "Practical Wide Arae Database Replication" Technical Report CNDS-2002-1 Johns Hopkins University, http://www.cnds.jhu.edu/publications
[18] Kondoro, J.W.A and Nungu, A. (2007). ICT for Rural Development Project: Provision of ICT Access to Rural Tanzania. In Proceedings of Towards Multidimensional Partnership in Promoting Use and Application of ICT for Rural Development Workshop. Dar es Salaam, Tanzania.
[19] Simba, F. (2005). Implementation of Internet Protocol Virtual Private Network (IPSec-based VPN) in Tanzania. M.Sc Thesis. Department of Physics. University of Dar Es Salaam, Tanzania.

International Science Index, Educational and Pedagogical Sciences Vol:3, No:6, 2009 waset.org/Publication/8011