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INVESTIGATING THE TELECOMMUNICATION NETWORK INFRASTRUCTURE IN GHANA TO IDENTIFY AN INFRASTRUCTURE CAPABLE FOR BUILDING NATIONAL RESEARCH AND EDUCATION NETWORK (NREN) IN GHANA

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Abstract

The paper aims at investigating the telecommunication network infrastructure in Ghana to identify an existing infrastructure that can be used to build a National Research and Education Network (NREN) in the country. NREN is a vital national education and research asset, but all efforts towards building one in Ghana are for now directed towards laying new expensive infrastructure. The study employs interviews, web search and visits to some sites of special telecommunication infrastructure in the country to achieve the stated objective. Findings reveal that the infrastructure layouts of the major telecommunication service providers have been examined, (thus national and institutional coverage), but the network for the e-Government network infrastructure system presents a superb case of the intent of the writers. We thus present details of the infrastructural layout of this network, but just presented brief discussion on that of the Internet service providers. We conclude that future research efforts towards NREN building in Ghana should be geared towards planning the deployment and how to fund it since this study is limited to only how to identify telecommunication infrastructure for NREN.

Keywords: Infrastructure management, Fiber optic, NREN, VHF radio, SERENATE, Bandwidth

INTRODUCTION

As Information and Communication Technology (ICT) inevitably becomes the bedrock or platform on which nations, organizations and citizens for that matter thrive to see acceleration in development, concerted efforts are being made throughout the World today to explore and exploit optimal uses of this tool. Societies that embraced this holistically have seen speedy development in real terms, including social cohesion. But those who have not yet done that would agree that one crucial thing is remains; the gap between them(the-have-nots) and their counterparts (the-haves) in terms of access to information and its use keeps widening.

Information Technology (IT) resources are best deployed and utilized through computer and telecommunication networks. The main network available for the deployment of IT resources nationwide in Ghana as of now is the Internet. The use of the Internet comes with its associated challenges, including; unreliability, high cost of bandwidth and sometimes very slow in the country. Education and research institutions have thus found it challenging to optimize the use of IT fully.

It is in this vein that this study reechoes the significance of having a specially designed and deployed network, popularly called National Research and Education Network (NREN), for the academia. The paper aims at assessing available telecommunication infrastructure of all the Internet service providers in Ghana to find out the possibility of an available such infrastructure in the country capable of being used to build a NREN.

This research intends whetting the interest of the education and research institutions, the National IT Agencies (NITA), National Communication Authority (NCA), the Government, students, donor agencies and all who are interested in education and research to think of having a NREN in the country not only now, but also concentrate efforts in planning and funding of the facility.

While other writers on this topic described the general infrastructural requirements for building NREN in the country, in this paper we concentrate our efforts in investigating to identify telecommunication network infrastructure in Ghana that can possible be used to connect all the research and education institutions to be used to build a NREN for such institutions in the country.

LITERATURE ON THE INFRASTRUCTURAL REQUIREMENT OF NREN

A national research and education network (NREN) is a specialized network or Internet Service Provider (ISP)specially designed to supporting the needs of the research and education communities within a country. This network is uniquely distinguished or identified by the support

for high-speed backbone network, often providing dedicated channels for individual research projects**.**

According to Alex Twinomugish (2007), NRENs are Networks that provide connectivity and services to users in research establishments and institutions of higher learning. They also offer very large network capacities (bandwidth) and various advanced services that are generally not available on the Internet**.**

The two definitions placed emphasis on two very crucial factors of the life of a nation; education and research. The resource requirement for these two sectors is so colossal that not even the most developed nations of the World would be able to adequately provide. Also returns on investment in these sectors are mostly not tangible; as a result resources are mostly diverted to supposed immediately rewarding sectors. This is especially so when it comes to Investment in Information Technology (IT) and Information Communication Technology (ICT); the cost is always very high and returns on investment are not immediately physically felt.

According to the GEANT2 report (Oct, 2007), NRENs provide the platform for students and the academic community to share and disseminate information through video conferencing and distance learning as well as sharing of computing and network resources through projects like GRID computing. GRID computing makes it possible for advanced software and vital but scarce scientific resources to be shared by remote institutions without having to equip their own networks with dedicated computing powers which are often associated with GRID**.**

Why nation should build and own a NREN

According to a SERENATE report D21 (Dec. 2003)investigating European NRENs, the education and research community has special needs that may not be met by commercial Internet and network service providers for a number of reasons that when consider together do not offer a business case for the commercial service providers to commit their scarce investment resources into, they include: The infrastructure, services and applications required for advanced research and educational needs are very expensive to provide and would require significant investment; the education and research community is not one with a very significant purchasing power; the education and research community is small in size compared with the private business sector and the general public.

The report argues further that for commercial network service providers, it would be more prudent and lucrative to concentrate on providing services to businesses and the general public; a market that requires comparatively less investment and offers a faster return on investment.

That notwithstanding, education and research are so crucial to the socio-economic development of a nation that one does not have to consider only immediate returns on investment as a major determinant or indicator to inform commitment of resources into the sector. As a result, the academic and research community may often have no option than to collaborate and pull resources together, to build, own, operate, manage and use their own dedicated networks.

This is especially even more crucial in our contemporary World that is driven by ICT and its related technologies with the capabilities of building electronic libraries (e-libraries), portals for electronic learning (e-learning)environments and others; it would be prudent to build such facility to provide a single platform on which Ghanaian educational institutions and the research community in particular would thrive on to collaborate, use and share very vital but scarce national education and research resources.

Benefits of NRENs

National Research and Education Network (NREN)as discussed earlier has multi-benefits to the NREN community, but the Summary Report on Serenate studies discussed them better, according the report, the following benefits are conspicuous:

- **Cheaper and more bandwidth**

The NREN community can aggregate Internet access demand from all its members and leverage economies of scale to achieve lower prices and therefore more bandwidth for the same amount of money spent by the institutions.

- **Increased negotiating power**

The cohesiveness of the community expressed through and represented by the NREN, tremendously increases the negotiating power of the community. This negotiating power could be used to further reduce bandwidth costs and can even be extended to acquisition and management of many other forms of ICT resources.

- **More efficient use of bandwidth**

If well designed, NRENs help keep local traffic local, thereby reducing the amount of expensive international bandwidth required. By keeping local traffic within the core network, NRENs can also tremendously boost access to educational and research content such ase-journals and e-content by establishing local mirrors and edge caching servers.

- **Increased influence**

The Nordic's countries NORDUNet puts it best: by speaking with one voice, the Nordic countries have much more weight in international networking collaborations. This sort of influence makes lobbying more effective and can be used to promote the interests of the community among private industry and governments, Kaarina Lehtisalo (The History of NORDUnet).

- **Increased collaboration and a sense of communism**

NRENs by their very nature promote collaboration and foster a distinct sense of communism among researchers, academics and the wider educational community. The fact that NREN creation requires collaboration between educational and research institutions reinforces the collaborative community approach to tackling challenges, sharing resources and collectively benefiting from the NREN.

- **Shared expertise**

Most African educational and research institutions (Ghana not an exception) cannot afford individually, to hire people with skills such as those possessed by advanced networking specialists, network security specialists and project management specialists. By forming an NREN, the entire academic and research community can benefit from centralized expertise and the cost to each institution is reduced as it is shared.

Attempts at creating NREN in Ghana

Ghanaian institutions of higher learning (the Universities) and research institutions tried using different networking technologies over the years with the aim of establishing connectivity amongst them. Some of the technologies used at various stages were dial-up modems, HF radio, VHF radio and fiber optics as the network platform, Barfi-adamako Owusu (2007)**.**

These were achieved through initiatives of the various institutions and donor funded projects like Fidonet (IDRC), Inter Lending and Document Delivery (ILL/DD), DANIDA and Ghana National Committee for Internet Connectivity (GNCIC). The closest they have come to establishing a true National Research and Education Network has been the formation of Ghana Academic and Research Network (GARNET) which had membership from some of the institutions mentioned above, the universities of the country according to Barfi-adamako Owusu**.** Up-to-date though efforts are being made to popularize the idea of NREN, it has not gained the needed popularity yet due to some administrative and technical bottlenecks.

Barfi-adamako Owusu (2007), in his document titled “on Network infrastructure to support research and education network in Ghana”, identified the following as reasons why GARNET has not gain its feet yet:

- **Organizational lapses**

At the organizational level, the mode of operations and composition of management was not clearly defined. This led to the situation where other institutions felt the project had been hijacked by a particular institution and therefore felt reluctant to participate fully,

- **Lack of top management support**

GARNET also did not receive full backing and support from top university administrators and this might have contributed to its difficulty in gaining recognition and hence popularity,

- **Lack of financial support from member institutions**

The financial contributions from member institutions were also not forthcoming because the modalities for payment were not well outlined between the Ghana National Committee on Internet Connectivity (GNCIC), the service provider, and the institutions involved,

- **Lack of effective and reliable Campus Area Networks (CANs) in the various campuses**

The earlier attempt at networking Ghanaian Universities to create NREN for the institutions of higher learning and the research institutions suffered a defeat because most of the institutions had not got well established Campus Area Networks (CANs). For NREN to function well to serve or connect institutions, various institutions need to have internal networks up and running.

- **Lack of trained personnel to man the networks**

Probably the most important factor responsible for the inability of Ghana to have effectively running NREN in the country now is the lack of trained personnel (both technical and managerial) to build and man the network. The earlier attempt might have not taken into consideration the crucial role of training staff to effectively manage such networks.

It might have not been able to be realized due to a greater extend, on the lack of Ghanaians with the requisite skills that may develop, maintain and advise on upgrading and overall management of such systems.

- **Inadequate education on the need and importance of NRENs**

Some of the factors cited as the reasons for the failure of earlier attempt at creating NREN include lack of top management support, lack of financial support and organizational lapses. These issues may be the result of inadequate education on the need and benefits of NREN to the institutions and the nation as a whole.

Infrastructural requirement to consider in setting up NREN

In building a national research and education network, certain requirements are crucial. The most important infrastructure required, the physical telecommunication network, is discussed in the section that follows.

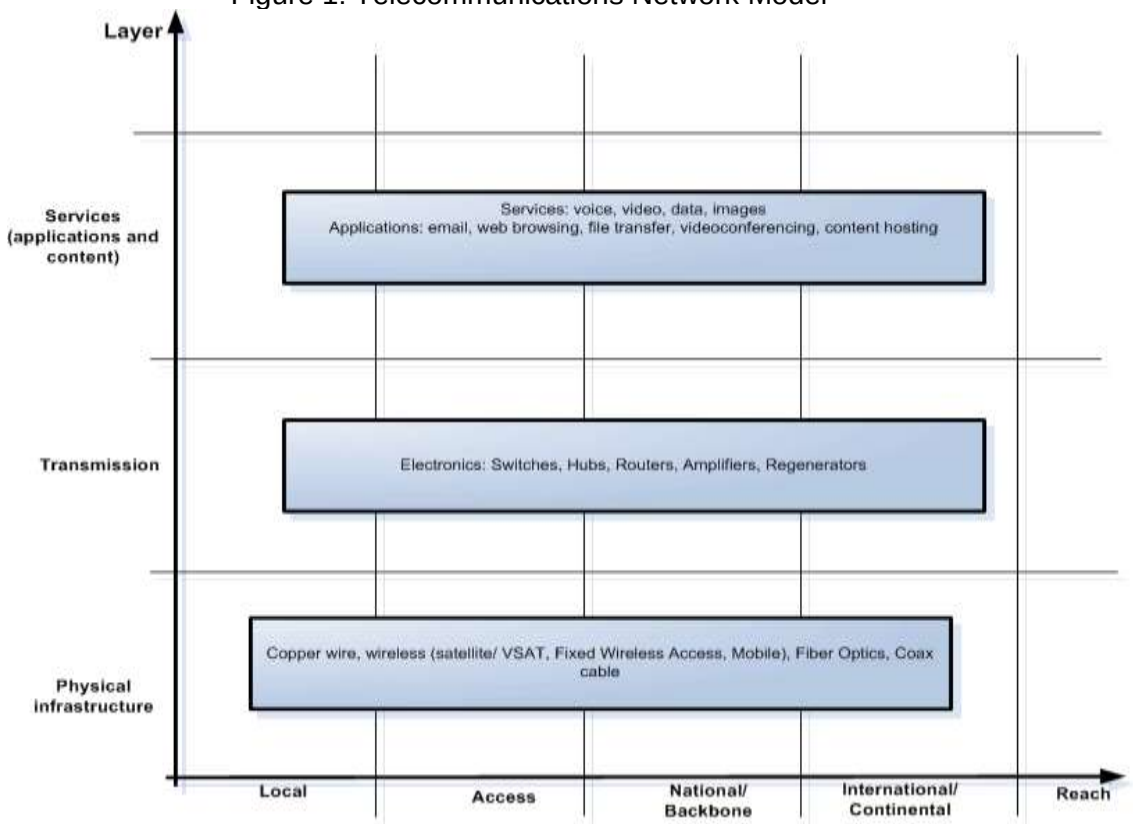
The physical telecommunications network model

One of the crucial factors to consider in setting up a NREN is the telecommunications network infrastructure.

The deployment of telecommunication infrastructure is also based on a layout structure called the telecommunication network model. The layered network model discussed in the InfoDev report on Open Access, Spintrack AB (2005) is informative.

The model consists of three dimensions: layer, reach and type of customer. For NRENs, the important dimensions are the layers and the reach according to the report. From the Open Access model, one can derive a model for NRENs as shown (figure 1).

Figure 1: Telecommunications Network Model



Source: InfoDev, 2005, Open Access Models

There are three layers: the passive physical infrastructure, the logical transport and transmission system and the services (applications and content).

The interface between layers is typically standardized by technical protocols and agreed upon business contracts and Service Level Agreements (SLAs).

The reach of the network is the geographical scope of the service providers. Another way of looking at this is that telecommunications network consist of various levels each with a distinct geographical domain and each level often provided and managed by a different organization. According to the model there are four main levels or geographical domains of

interest to NRENs: local, access (metropolitan or regional), national and international levels (figure 1). Networks at various levels are usually interconnected through **points of presence** or **POPs**. The networks associated with the various levels are detailed below:

- The ***local network*** is the internal institutional network commonly called the **campus network** and this is the network closest to the end user (figure 1). The local network is owned and managed by the institution.

- The ***access network*** is the portion between the institution and a high speed, usually nation-wide network (or the national backbone) (figure 1). It is also known as the **last mile**.The access network is usually owned and managed by different commercial ISPs, telecommunication services resellers and major telecommunications companies. Examples of access networks include Metropolitan Area Networks (MAN) and other Regional Networks.

- The ***national network*** or national backbone is the high-speed network linking major towns and cities in a country usually owned and operated by the national or other major telecommunications companies (figure 1).

- The ***international network*** connects the national network to other national networks or to continental or international networks (figure 1). It is also usually owned and managed by national or other major telecommunications companies.

The access and national backbone segments of the network are usually collectively referred to as national infrastructure. In Ghana, like most African countries, these segments of the telecommunications network are usually of low capacity which makes it unreliable and only available in the major metropolitan areas.

The reach of NREN networks

The reach of NRENs in relation to the telecommunications model discussed above usually involves 2 or 3 levels: the ***access network***, the ***national network*** and the ***international network***. The ***local network*** in most cases is provided by the institution. The other 3 levels are discussed below:

- **NREN Access Network**

Some NRENs do not provide the access network, instead, they provide **POPs** on their nationwide (or core) networks for institutions to connect to other NRENs provide an access

network or extend the core network directly to the institutions (the majority of NRENs in Europe connect directly to the institution).

As acknowledged by the SERENATE summary report Deliverable D21**,** direct connection is usually more feasible where there are a few institutions. When the number of member institutions is in the hundreds or even thousands, NRENs will usually provide **POPs** in major cities and towns and institutions may have to obtain their own access connection individually or collectively.

- **NREN backbone or core networks**

All NRENs provide a nation-wide high speed network also known as the **core or backbone** network with **POPs** at which institutions connect to. This core network allows institutions to exchange traffic directly to aggregate traffic destined for other NRENs or international networks. The core network can be provided over fiber, the traditional copper cables or via radio networks although most NRENs in the more developed world have moved to fiber only core networks, SERENATE report Deliverable D14.

- **International connections**

NRENs also usually provide link(s) to international or continental Research and Education Networks (RENs), for example in Europe most NRENs connect to GEANT, which in turn is peered with major commercial telecommunications service providers and directly connect to the commercial Internet .

The connection to the commercial Internet is usually through a peering arrangement. According to the SERENATE summary report Deliverable D14**,** it is the general policy in Europe that NRENs should off-load traffic with a destination in the commercial Internet onto the networks of commercial Internet Service Providers (ISP) at the earliest economically viable opportunity which usually means offloading to the nearest Internet Exchange Point after which this traffic is carried by a commercial ISP.

Local vs. National vs. International Connectivity

When it comes to aggregating bandwidth, most institutions in Ghana seem to focus on international bandwidth and seldom, consider the national and local bandwidth requirements. Perhaps the drive for connectivity has been to access information resources and for basic communication like e-mail, which as the AAU bandwidth Initiative report notes, is still the assessment of information resources on European and American servers which puts excessive load on international bandwidth capacity. Further, if institutions are connecting by VSAT directly to the international backbone, as is often the case in our country, the issue of national bandwidth does not arise.

However, NREN connecting the institutions of the country would among other things have to holistically consider its access, national or backbone and international bandwidth portions. The three reasons why this is important include:

a) Increasing international bandwidth without paying attention to access, national and even local bandwidth might be a waste of valuable funds. If the local and national networks are congested or slow, they will act as bottlenecks making it impossible to maximize the use of international bandwidth.
b) National rather than international bandwidth is the drive for local inter institutional collaboration and for sharing expensive resources such as supercomputing facilities or e-content within the country.
c) A very crucial point worth noting is, sometimes access and national bandwidth are as expensive as the international bandwidth, they may at times be, comparatively, more expensive so if more attention is paid to the international bandwidth to the neglect of the local, the optimization of bandwidth benefits may not be fully realized.

The issue of local institutional connectivity is worth emphasizing. The AAU Bandwidth initiative report (ICT and bandwidth initiative)acknowledges that good local infrastructure and policies are preconditions for the efficient exploitation of expensive bandwidth resources.

The SERENATE report on the networking needs of users in the research community in Europe also finds that the major source of limited network performance is primarily at the campus level. The report recommends that the attention of senior management at institutions hoping to connect to NREN be drawn to this fact. The report also acknowledges that convincing institutions to invest in their campus networks is remarkably difficult even though such institutions spend close to six times or more money on other infrastructural services like telephony, electricity, water and heating and other such facilities. Clearly this is a challenge that the quest for NREN connecting institutions of Ghana would most likely come face to face with.

NREN network ownership models

According to the SERENATE report discussing the future scenarios for the funding of network infrastructure in the European research networking community and of related costs, Morten et al (2003) there are four main ways (or models) by which NRENs can acquire and deploy their networks. They include:

i. Model 1-Build own infrastructure

NRENs can build their own networks (full ownership) or partner with other service providers (e.g. through joint venture). This would involve laying own fiber and providing necessary

transmission equipment or by deploying wireless systems such as microwave links. The NREN (or its joint venture partner(s)) can operate and manage this infrastructure itself or outsource the operation and management.

ii. Model 2- Lease infrastructure

NRENs can lease existing but unused infrastructure e.g. dark fiber from telecommunications service providers or other entities such as electricity and rail companies. In such case, the NREN would provide its own transmission equipment (amplifiers and regenerators for fiber systems or antennas and transceivers for microwave system with the provider availing towers, power and backhaul links).

iii. Model 3- Purchase managed services

NRENs would lease dark fiber or dedicated wave lengths on fiber or dedicated channels on microwave links with the telecommunications service providers owning all transmission equipment

iv. Model 4- Purchase capacity

NRENs would purchase capacity or bandwidth from service providers between two or more points. In this case, the NREN network is usually a Virtual Private Network (VPN).

The Models discussed above and the costs requirement associated with each, the relationship with other service providers and technical expertise required (considering only the NREN core network) is presented in a tabular form below:

	Initial cost	**Recurrent capacity cost**	**Existing providers' capacity required**	**Existing providers network coverage required**	**Technical expertise required**
Model 1	Very High	Nil*****	Nil**	Does not matter	Very high
Model 2	High	Nil*****	Nil******	High	High
Model 3	Medium	High	High	High	Medium
Model 4	Low	High	High	High	Medium

* With Model 1 and 2, NRENs still incur recurrent costs of maintenance and servicing of their connections and transmission equipment but do not incur monthly bandwidth charge.

** Models 1 and 2 do not require that existing service providers which have high capacity networks as they do not rely on existing capacity.

Approach to selecting ownership model

The ownership model(s) selected may vary from country to country depending on a number of factors as shown in the table above. They include:

- Regulatory regime
- Financing or funding options available
- Level of technical expertise available to the NREN
- The amount of short and medium term bandwidth/capacity requirements
- The types of applications that the NREN will support
- The extent, coverage and capacity of existing service providers' infrastructure

It is worth noting however, that the relative implications of these factors may vary, sometimes greatly, for different countries. And so, the analysis made could only be taken as a guide. The information required to actually make a decision on the most appropriate model requires a careful study on the existence, reliability, performance and gaps in the national infrastructure. This could be very crucial preliminary considerations in NREN development.

A very informative and comprehensive study conducted into the most appropriate model required for NREN creation in Africa has being the SARUA study on Optical Fiber for Education and Research Networks in Eastern and Southern Africa, BjörnPehrson(2006). Such studies would map the existing and planned coverage of the national high speed backbone and access networks (preferably of all the service providers in the country) to the locations of all educational institutions.

This survey would be extremely useful in determining where the gaps in infrastructure are, the existence and feasibility of using dark fiber and the current and potential capacities of existing infrastructure. The study of national infrastructure would also provide essential input into a suitable network design for the NREN.

Traditionally, NRENs in Europe and other parts of the World had to simply, as a start, purchase capacity from existing service providers and created VPN type networks possibly because this model does not require NRENs to outlay large amounts of money for infrastructure provision. However, European NRENs are now increasingly deploying their own infrastructure or leasing dedicated infrastructure.

Telecommunication (ICT) infrastructure in Ghana

The broad ICT sector in Ghana is relatively small, but very dynamic and fast growing which is the result of a combination of factors. The growing use of ICT can be attributed to the increased

levels of investment in telecommunication infrastructure and other key parastatal and government service providers, government policies and private participation in the ICT sector in general.

The Government of Ghana has been pursuing policies and reforms to improve on the development of ICT in Ghana. The liberalization of the telecom sector in Ghana started in the 1990s; allowing private participation to complement the activities of the then Post and Telecommunication Corporation. It further opened up the telecom market to allow the sale and installation of terminal equipment according to Frempong, GK (2004). The National Telecommunication Policy of 2005 further seeks to promote private participation and ownership of public telecommunication infrastructure and services. Through these initiatives the Government of Ghana sold seventy percent (70%) of her shares in Ghana Telecom (GT) to a British telecom company, Vodafone, and there are plans to privatize government's shares in Westel Telecom (Kasapa) and Volta River Authority (VRA) Voltacom networks, Ghana Telecommunication Policy Document (2005).

Some of the objectives of the Government as documented in the policy document are: to provide universal access to telecommunication by the year 2010 with the expected tele-density of25%, and provide connectivity to all schools, hospitals and government agencies.With the liberalization of the sector in the early 1990s the country saw a number of telecommunication companies into the country to do business.

Currently we have as many as five telecom companies operating in the country, with the sixth (GLO) yet to gain grounds. The five companies are: MTN, tiGO, Vodafone, Kasapa and Airtel. Among these companies, Vodafone, Glo and MTN have deployed fiber optic cables almost country wide in addition to Volta River Authority (VRA) fiber network.

However, the National Communication Backbone Company (NCBC) is built on the Vodafone fiber infrastructure. For the purpose of this research work, we limit ourselves to the assessment of the three main companies whose fiber networks are operational in the country; VRA, Vodafone and MTN.

Volta River Authority (VRA) integrated fiber-optic network

The VRA is a power transmission company responsible for the provision, generation and distribution of electric power in Ghana. It has a reputation for an efficient internal telecommunication system linking its offices located in different parts of the country. According to Owusu Barfi-Adomanko (2007) it has over the years built a fiber optics backbone along its transmission lines in the southern part of the country. There are 15 nodes on the network;

covering a total distance of 882 kilometers in five administrative regions - Eastern, Western, Central, Greater Accra and Ashanti (Fig. 2).

Figure 2: VRA integrated fiber-optic network southern belt

Source: Ministry of Communications, Ghana

Two out of nine pairs of fibers are used for VRA corporate operations with the remaining seven serving as dark fibers. The backbone capacity is 155Mb/s (STM-1). The type of fiber optic cable deployed by VRA is optical ground wire (OPGW). OPGW is a composite of ground wire to provide lightning protection for overhead power lines as well as a fiber optic cable for high performance telecommunication network. It has also been proven to be more reliable and provides higher availability as compared to other types of fiber.

This provides an option for building the NREN backbone on this network when the need to interconnect the institutions of higher learning and researches institutions becomes a reality. The other institutions can be covered with the expansion of the backbone of the government of Ghana currently in progress.

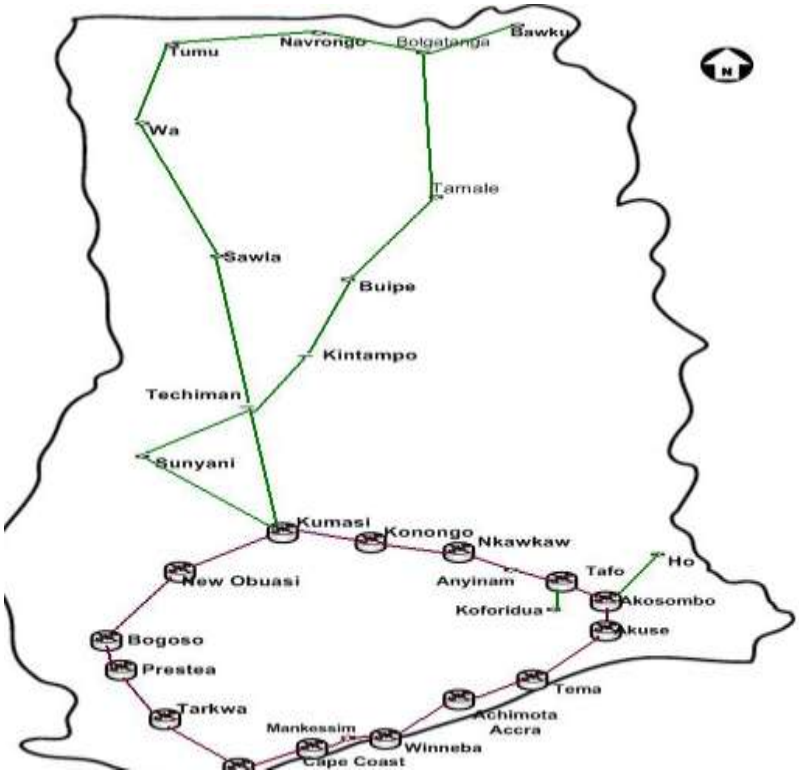
The new national fiber optic backbone

Government being aware that the ICT market is fast growing in Ghana, she is thus keen to seeing the VRA fiber network brought into play to enable further development of services and roll-out of services to areas not currently served. The fiber network is seen as the only national network resource, which will not suffer from bandwidth limitations in the near future and as the logical foundation on which to build a more extensive national optical fiber network. The new national communications backbone infrastructure is to compliment the VRA fiber network in the Southern Sector.

The Government of Ghana through this project will expand ICT to other parts of the country more especially the northern sector. The Government believes this will lead to reduction of cost of ICT services and also make ICT accessible to majority of the population. It has therefore secured a loan of $US70 million for the expansion project. It has already received $50 million out of the total credit facility for the commencement of the project revealed, Owusu Barfi-Adomako (2007)

The list of towns and cities where the new link will terminate are Mankessim in the central, Sunyani, Techiman, and Kintampo in Brong Ahafo region; Anyinam, Koforidua and Kpong in the eastern region, Ho in the Volta region, Tamale, Buipe and Sawla in the northern region, Wa and Tumu (Upper West), Navrongo, Bolgatanga and Bawku in Upper East region (Fig.3).

Figure 3: Proposed new national communications backbone infrastructure



Source: Ministry of Communications, Ghana

The new project will make use of the existing VRA power transmission and duct and bury fiber where they are not served by these lines. Koforidua, Anyinam and Ho are off the power transmission lines and cannot be part of this phase of deployment.

The reason being that, the type of fiber optic cables (OPGW) are laid alone the transmission lines to serve the dual purpose of ground wire to provide lightning protection for overhead power lines as well as a fiber optic cable for high performance telecommunication network.

Vodafone Company

The Vodafone Company (formerly Ghana Telecom) is one of the telecommunication companies in Ghana with a bigger share of both networking infrastructure and customer base. The company was privatized in 1997 through the sale of 30% shares to G-Com Ltd, a consortium led by Telecom Malaysia Berhard. This Management Contract with G-Com Ltd was however abrogated by the Government of Ghana in 2002. The government entered into a Management contract agreement with Telenor Management Partner (TMP) in February 2003 to implement TMP Business Plan it had developed for GT covering the period 2003 to 2007 according to the VRA office. Vodafone telecommunication infrastructure supports the public and some of its user base to make use of advanced information technology applications for long distance learning, e-banking, e-business etc. Its GSM services (formerly OneTouch) has international roaming agreements with about 150 mobile phone service providers in the world and its General Packet Radio Service (GPRS) services was launched in November 2006, according the office of Ghana telecom, Tamale.

Vodafone Data Communication Networks

Vodafone has built an MPLS backbone network to interconnect all the regional capitals in Ghana. Because of its limited bandwidth capacity of only 2Mbps it is upgrading some parts of the network with fiber optics cable to meet the ever growing demand for broadband services. The project has two components; Inter-city and intra city backbone. The intra-city projects are in Kumasi and Accra. The Inter-city is being built on existing VRA Integrated network following a Memorandum of Understanding signed between the two companies, revealed by the officer.

Mobile Telecommunication Network (MTN)

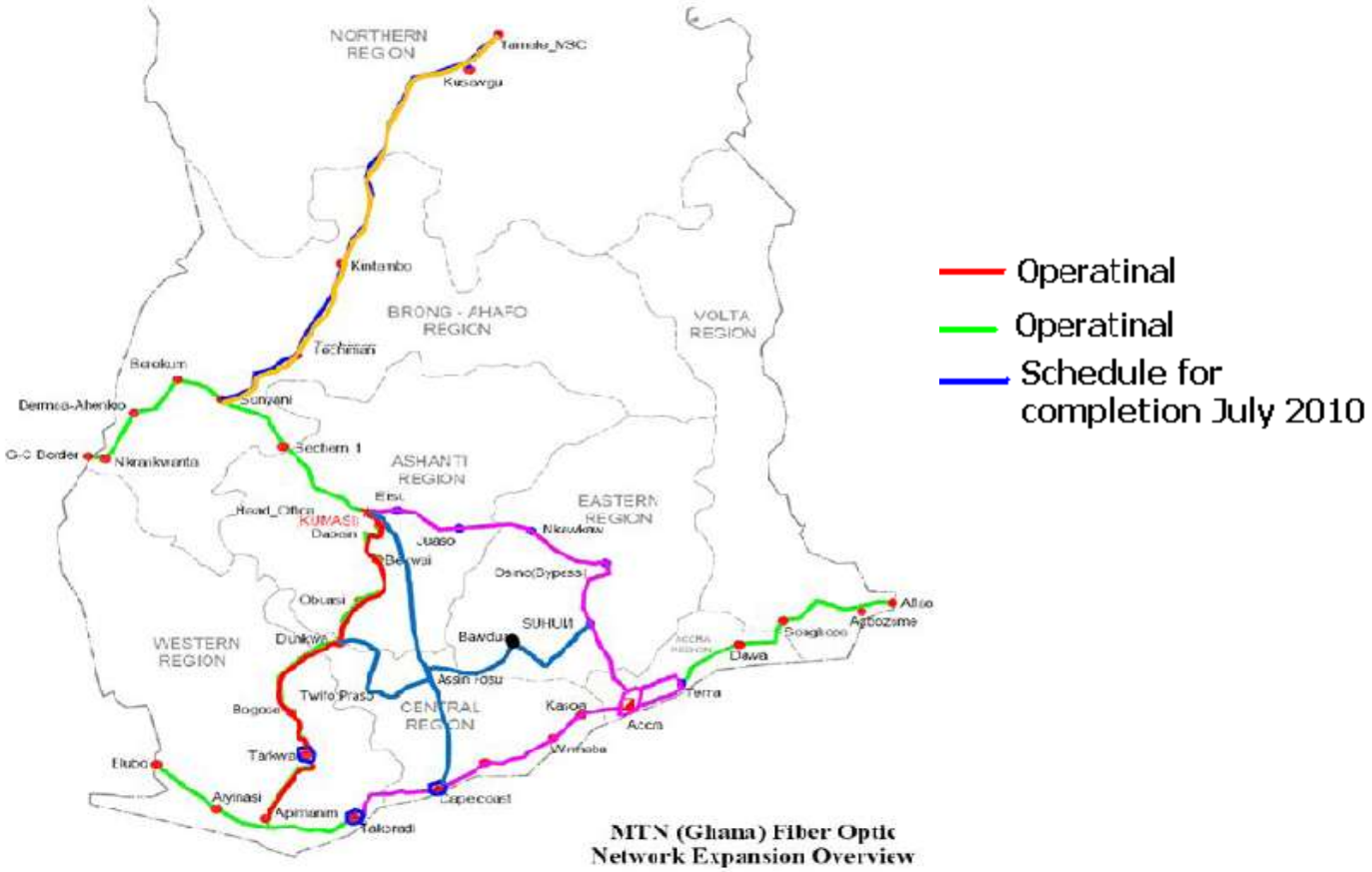
MTN is one of the Telecommunication companies in the country providing both voice and data communication services. MTN has the biggest share in terms of customers in the country.

The company started business in the country in the late 1990s under the name Spacefone. The name was later changed to Areeba and currently MTN after Investcom bought 98 per cent of Scancom shares, MTN Regional Management, Tamale.

MTN Data Communication Networks

Like Vodafone, MTN has built a fiber optic backbone to link the major cities in the country starting from the coastal cities through Kumasi to Tamale in the Northern part of the country (figure 4). This could be in response to the increasing demands of bandwidth by its numerous customers in voice and data.

Figure 4: MTN (Ghana) Fiber Optic Network



Source: MTN Ghana

Emerging opportunities for NREN in Ghana

Our study is focused of identifying telecommunication network capable of being used as infrastructural base for the deploying of NREN in Ghana. To that extend, we investigated the network infrastructure of the various networks of the telecommunication service providers in the country, including; **Vodafone**, **MTN**, **tiGo**, **airtel** and **GLO**. In addition to the infrastructure, we also studied their network coverage areas in the country.

In the course of the study we came across a network infrastructure (e-Government network) which has been deployed with the towers and the microwave links fixed. We have thus concentrated our efforts on detailed study of the infrastructural map of this network and the nation coverage to make a case to be used for building of NREN.

We have as a result not discussed details of other networks since this would most likely meet our objectives than the other networks.

There have been significant emerging trends and initiatives in Ghana that could be of interest in the quest to design NREN in Ghana as they could be exploited for the development of the network. Some of these trends and initiatives are discussed in the follow;

National backbone

The country has successfully designed, extended and upgraded the existing national backbone. It has been built or extended to areas where higher educational institutions or social organizations are located. The network could be availed to the NREN with dedicated capacity in an attempt to realize NREN in Ghana. This offers the crucial opportunity or hope in the quest for NREN development in Ghana.

E-government initiatives

In November 2008, parliament of Ghana approved a $30 million concessionary loan facility that has been extended to the government of Ghana by the government of China for the construction of the initial phase of a nationwide e-Government infrastructure.

The proposed infrastructure would extend the national backbone infrastructure to all districts in the country and provide a national data centre and a secondary data centre facility for disaster recovery capability, and ultimately connect all public institutions; Ministries, Departments and Agencies (**MDAs**) and Municipal, Metropolitan and District Assemblies (**MMDAs**) to a single shared communication and computing infrastructure to facilitate effective delivery of government information and services to citizens, businesses and others, GGEA Resources (2009), GIF and Project Briefing.

The local subsidiary of the leading Chinese telecommunications equipment manufacturer, Huawei Technologies (GH) S.A. Ltd. has been indicated as the implementing contractor for the project, which will be delivered on a turnkey basis to the government of Ghana. The Ministry of Communications subsequently tasked Ghana Information Communication Technology Department (**GICTeD**) with the responsibility of working with Huawei to realize the implementation of the project, according to the document.

Under the proposal for an e-Government network to be built by Huawei, the network was configured to reach up to 1050 sites around the country; 550 locations via wireless last mile access networks and an additional 500 locations via any other means.

The target sites are intended to be reached via several different means, including direct fibre optic connectivity, high capacity microwave links, VSAT access over the Ministry of Finance and Economic Planning (MoFEP) network and leased terrestrial circuits from local telecommunications and ISP providers.

This will enable the network to connect not just the district assemblies, but also hospitals, schools, police stations, agric extension service offices, research institutions, and any other such public offices or institutions in all the towns that are within the coverage area of the network.

The programme was launched on August 3rd 2010 in Accra at the Kofi Anan ICT Centre of Excellence by the then Minister of Communication with the aim to, in addition to transforming governance by making it more accessible, effective and accountable to the people;

- Provide greater access to government information
- Promote civic engagement by enabling the public to interact with government officials online
- Make government more accountable by making its operations more transparent and through that reducing corruption as much as possible
- Provide development opportunities, especially benefiting rural and traditionally underserved communities
- Strengthen democracy and make governments more responsive to the needs of her citizens
- Monitor the activities and operations of the Ministries, Departments and Agencies (MDAs)

Objectives of the e-government project

GICTeD has developed a deployment strategy for achieving the stated policy objective of reaching all 170 districts in Ghana, and working together with the implementing contractor, Huawei, finalized a design for the national e-Government network to ensure that the network will serve the widest possible diversity of Ministries Departments and Agencies as well as Quasi-Government Institutions, Organizations and Corporations.

The network infrastructure solution as proposed will deliver the following:

- The e-Government network infrastructure will be built upon previous investments by the Ministry of Finance in fibre optic connectivity between key MDAs in Accra, and will utilize capacity from the national communications backbone company, (NCBC) which is now a part of Vodafone Ghana
- The project will provide additional network switching and routing equipment to refresh a lot of what is currently installed at the MDAs to be served by the project
- The network infrastructure will in addition to fibre optic capacity, include wireless last mile connectivity over most of Accra, all the regional capitals in the country, and up to ten (10) additional municipal and district capitals that are located in close proximity to the national fibre optic backbone
- The project will provide equipment for connecting up to 550 MDA facilities to the wireless last mile access network
- The project will provide for the interconnection of all the ministries in Accra with fibre optic cable, with the core network running at 10Gbps (Gigabits per second) and all ministries enjoying a minimum connectivity speed of a 1Gbps with each other and to the National Data Centre
- The network will provide a single secure gateway to the internet and implement services such as access control, spam filtering, firewalls and anti-virus defences for the government network as a whole and between the individual MDAs as may be required.
- The network will also provide for the centralization of all government voice and fax traffic within the network and directly interconnect all the existing PABX of connected MDAs and MMDAs, saving the government hugely on the cost of inter agency communications.
- Brand new IP PABX switch components will be installed at the larger MDA locations to provide voice circuit termination and forwarding facilities.
- Local area networks (LANs) in all the Ministries in Accra will be upgraded and equipped under this project and several new LANs will be deployed in various beneficiary Assemblies and MDAs in the regions and districts. In all a total of 6300 LAN ports will be deployed at the various beneficiary sites to support both voice and data access to the network.
- All 170 district assembles in the country will be connected to the national e-Government network infrastructure by utilizing various terrestrial connectivity options.

- It is intended that the leased lines to each of the districts will tie-in with all other parts of the communications network and to the central monitoring systems at the Network Operations Centre (NOC)
- Government, through the Ministry of Communication (MoC) and GICTeD's facilitation, will negotiate bulk rates for acquiring leased lines from the local telecommunications operators and ISPs for the links from each district to the national fibre backbone.
- All the sites served by the network will enjoy substantial savings in telecommunications costs from the new network due to the automatic routing of all telephone calls that originate and terminate in a government agency over the e-Government network. This will lead to a substantial savings in domestic telephony charges for government.

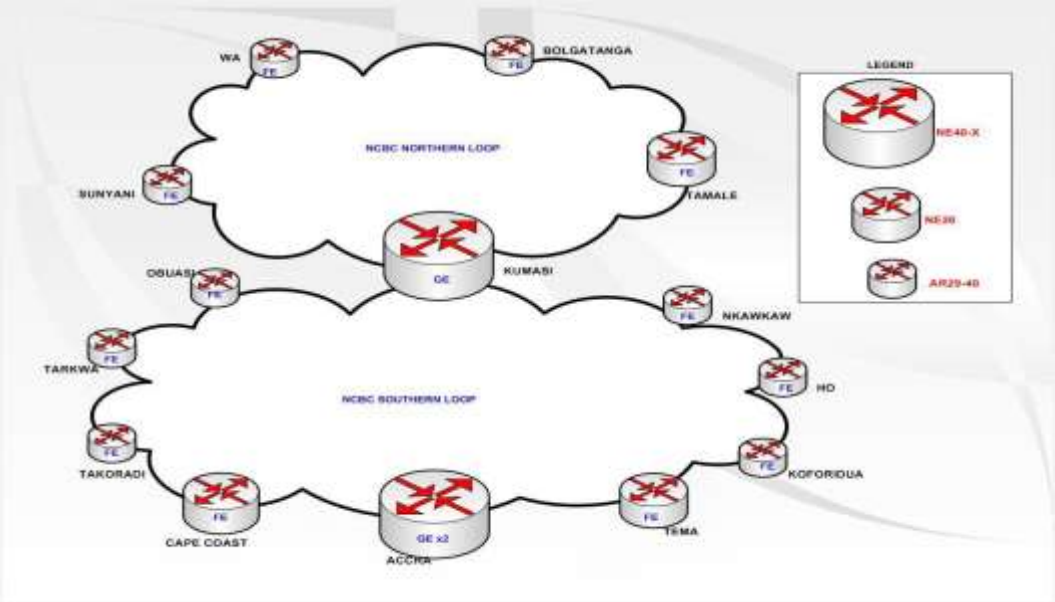
Benefits of the e-Governance System

1. The proposed solution will be achieved by building new infrastructure as well as deploying new equipment into the existing networks and fibre optic assets in the ground that were previously procured by the Ministry of Finance and Economic Planning.
2. The network has been designed with the objective of running at a low operating cost when compared to the total investment in the e-Government network and will allow for cost effective scaling up as the capacity and geographical coverage requirements increase.
3. The proposed solution will foster the participation of local communications network operators in the e-Government network.
4. The proposed solution will allow much higher bandwidth links to each district than MoC or Ghana Government (GoG) could otherwise afford from the commercial telecommunications service providers.

Internet protocol (IP) backbone

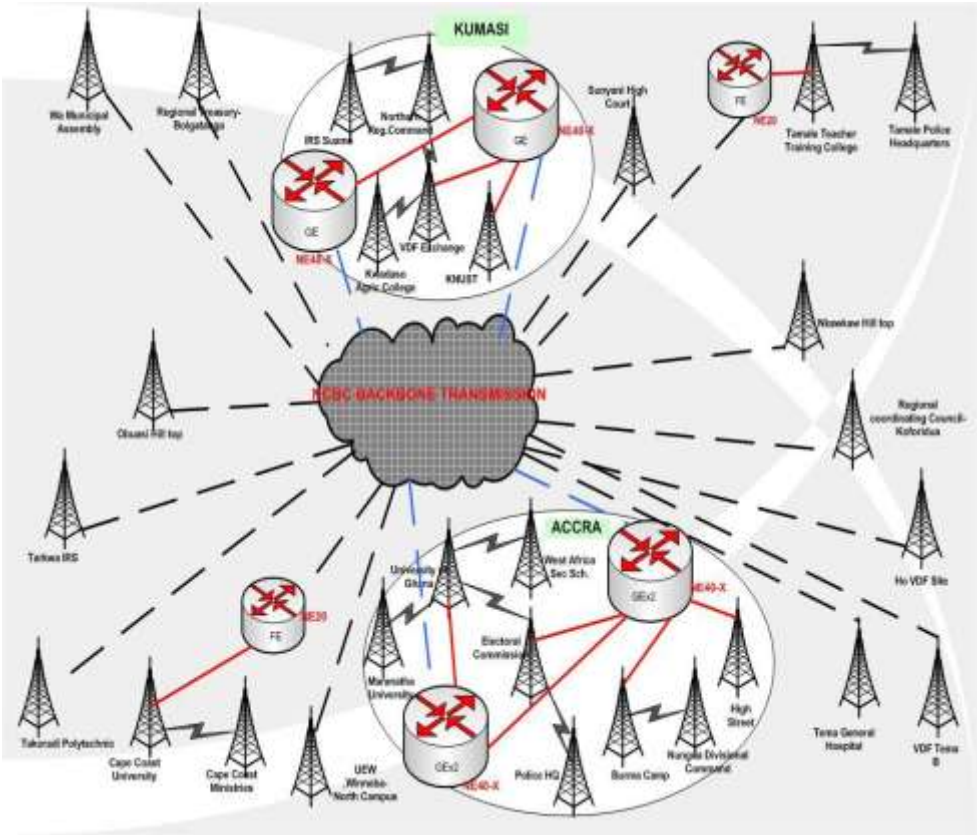
In order to link all the 15 towns and cities that will have WiMAX coverage, the network will be built on an IP backbone that will run over the infrastructure of the National communication backbone company (NCBC), a subsidiary of Vodafone Ghana, which manages the national fibre optic backbone infrastructure. The IP backbone will initially operate at the speed of Gigabit Ethernet (GE), and should support easy expansion to 10 Gigabit Ethernet speeds (figures 5 and 6).

Figure 5: IP Backbone of e-Government project



Source: Document, Launching of Ghana Government Enterprise architecture

Figure 6: The WIMAX BTS physical layout across the regions in Ghana



Source: Launching Document of Ghana Government Enterprise Architecture

The Ghana Government has installed wireless equipment on the various campuses of the MDAs to create a network to effect that will enable the achievement of the functions outlined above. The physical infrastructure as discussed above, have been successfully deployed. The Base Transceiver Stations (BTSs) in Tamale have been installed at Tamale College of Education (TCoE) and the Tamale Police Headquarters (figures 7&8) respectively, to link all the educational institutions (including second cycle institutions) in the education ridge area and the government departments and agencies, including the police station, hospital, judiciary and others respectively.

Figure 7: E-Government BTS site (Tamale 1) at Tamale Teacher Training College

Figure 8: e-Government BTS site (Tamale 2) at Tamale Police Headquarters

The Huwawei FE OptiX OSN 3500, an intelligent optical switching system with “dual core" architecture have also been installed the regions and districts as nodes in the various sites as shown in figure 8. In the Northern region, the installed sites are Buipe and Tamale (figure 9; near Radios Savanna) respectively.

Figure 8: The routing Node near Radio Savanna in Tamale

Also the VSAT installations have been done in the various institutions. That of Tamale Polytechnic has equally been installed (Figure 10).

Figure 10: VSAT on Tamale Polytechnic Campus, link to the E-Governance Access (Last Mile) Network

This network according to the Tamale office of Vodafone, have as many as seven (7) dark fiber optic cables in it. This makes a case for using this network to build NREN in Ghana. Reasons are that:

- the network has already been deployed
- it covers all the institutions such networks intends to cover
- with the availability of dark fiber on the network, means it can serve the purpose for which it was designed and comfortably used to build NREN
- the investment in the infrastructure is fixed, if it is use for the intended NREN, the initial cost still remains
- using it for NREN will would most likely come closer to optimizing the benefits of the investment

SUMMARY OF FINDINGS

Our investigation revealed that the e-Government network infrastructure covers all the Ministries, Departments and Agencies (MDAs) in the country of which the education and

research institutions are part. It also covers all Metropolitan, Municipal and District Assemblies (MMDAs). We showed evidence that the physical infrastructure of the network has been deployed in real and cartographic pictures. The revelation is that we have a real major national telecommunication asset in the nation that is being underutilized.

RECOMMENDATIONS

Upon the current detailed study in the telecommunication infrastructure network of the country, the e-Government network has covered the phase in the deployment of NREN. Efforts at building NREN in Ghana should be concentrated on other factors like;

- Lobbying with the appropriate authorities to make the network available for NREN,
- Education should now concentrate on importance of NRENs to nation development to whip up interest,
- Awareness creation should take the form workshops, seminars and publications of this nature to let the masses know about it,
- We recommend also that the next efforts towards NREN creation in Ghana should be geared towards how to fund NREN facility but not the infrastructure availability,
- We recommend that policy and implementation master plans be drawn to implement a NREN on the network
- Finally we recommend that the education and research institutions come together to form a unified force towards negotiations

CONCLUSION

Research and Education Networks are not fictions; they are realities that have been tested and proven in other parts of the World. Use of IT resources is optimized not on stand-alone bases, but networked environments. The network resource must be available, reliable and within the reach of the education and research populace in particular.

NREN is the network that provides these and more. We have identified a network already deployed in Ghana with the same features as NREN network. National and institutional coverage, physical network infrastructure are all deployed. We conclude that a closer look be given to our recommendations to enable us realize NREN in Ghana.

Further studies in the building of NRENs in Ghana could be done in the funding of such facilities. We also suggest further studies into the policy planning, implantation and legal issues involved in NREN building and management.

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