eGY-Africa: better Internet connectivity to reduce the digital divide

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Abstract: Adoption of information and communication technologies and Internet access is expanding in Africa. But, due to more rapid growth elsewhere, a digital divide exists between Africa and the rest of the world. Investment in fibre cable networks in and around Africa during the past few years opens the possibility of slowing the growth of this divide, and, hopefully, reducing it. At present, though, education and research in many sub-Saharan countries still suffers some of the worst Internet deficiencies, despite progress in the development of National Research and Education Networks (NRENs). By contrast, it is widely acknowledged in policy statements from the African Union and others that strength in this very sector provides the key to meeting and sustaining Millennium Development Goals. Countries with advanced cyber-capabilities proclaim the benefits to rich and poor alike arising from the information revolution. This is but a dream for many scientists in African institutions. As world science becomes increasingly Internet-dependent, they become increasingly isolated. eGY-Africa is a bottom-up initiative by African scientists and their collaborators to try to address this problem by a campaign of advocacy for better institutional capabilities. The present status of Internet services, problems, and plans are being mapped via a combination of

Information is being gathered on policy statements and initiatives aimed at reducing the digital divide, which can be used for arguing the case for better Internet facilities. Action groups of concerned scientists are being formed at the national and regional levels in Africa, building on existing networks as much as possible. Opinion in the international science community is being mobilized. Finally, eGY-Africa is seeking to engage with many other programs, initiatives, and bodies that share the goal of reducing the digital divide – either as a direct policy objective, or indirectly as a step towards other national development goals. The expectation is that informed opinion from the scientific community at the institutional, national, and international levels can be used to influence the decision makers and donors who are in a position to enable better Internet capabilities.

Keywords: Digital Divide, Internet connectivity, Research and Education Networks, ICT.

1. Introduction

Science and Technology, with their firm ICT base, are widely accepted as key factors for reducing poverty, ensuring socio-economic development, and reaching the Millennium Development Goals[1]. They are essential for the evolution towards a sustainable peaceful, integrated, and prosperous continent and for making Africa a full player of the global community. Growing indigenous research and education capability alleviate reliance on non-African sources, and reduce opportunities for overseas manipulation of African interests. The Africa Science and Technology Consolidated Plan of Action, formulated by NEPAD and the African Union, the creation of the African Ministerial Council on Science and Technology, and the African Regional Action Plan on the Knowledge Economy, are recent examples of Africa's determination to rely on ICT-based science and technology to achieve growth and development objectives.

We are living at the commencement of the information era, in which access to information and knowledge increasingly becomes the key factor that distinguishes rich from poor societies. The availability of, and ready access to digital information and ICT determines whether a community can participate in the remarkable benefits of the information revolution. In the area of science and technology, participation in the information revolution is particularly effective in delivering benefits to Society. But participation is conditional on having an ICT infrastructure that connects to the world community and the vast resources of available information and services. Communities that lack such an infrastructure are becoming increasingly marginalized instead of being empowered by modern developments. This is particularly true in the world of research and education, which has high Internet-dependency. For example, libraries are moving away from storing printed information, and it is almost impossible today to register for a conference or participate in an international project without effective access to the Internet.

Many organizations, initiatives, and consortia (e.g., GÉANT, INTERNET2, and UbuntuNet) share the objective of reducing the digital divide in Africa. Some have a domestic perspective and focus on the national benefits of reducing the divide, whereas others have an international perspective - they see the divide causing loss of African talent to the global scientific community. Most initiatives and programs see the need to address the digital divide issue as a necessary step towards achieving wider program goals.

2. Internet Penetration in Africa

Internet penetration (percentage of the population using the Internet) in Africa is compared with the rest of the world in Figure 1. The situation is improving rapidly with the installation of better optic fibre networks in and around Africa, but the digital divide between Africa and industrialized countries still means that the potential of African universities to play a key role in national development is not being fully realized. Measurements covering 99% of the world's Internet-connected population show that Africa is still about 16 years behind the rest of the world [1].

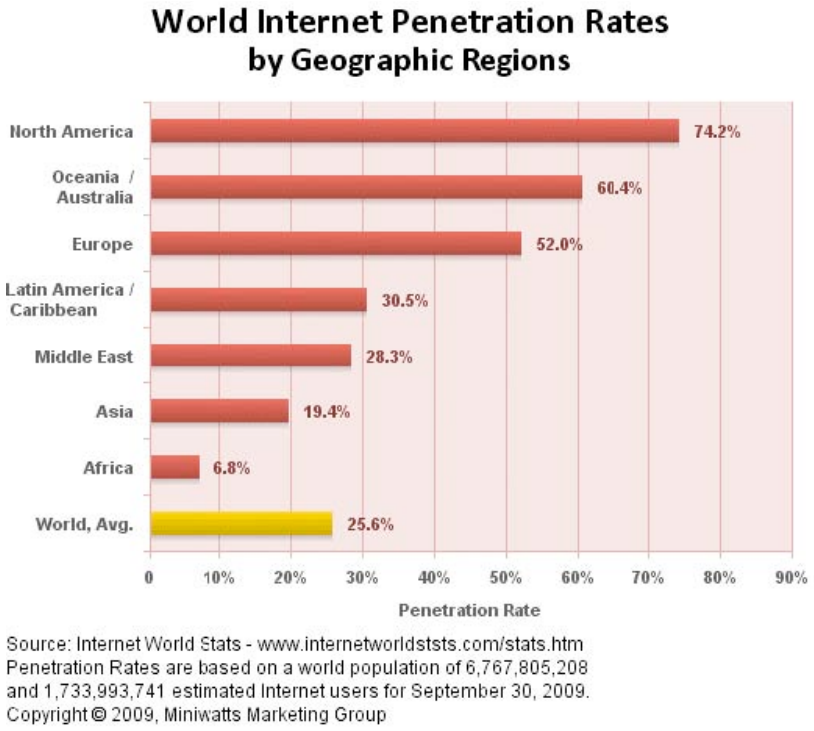

Figure 1. Internet penetration.

3. Data Archives

Most African data are stored outside Africa and African scientists need access to the vast stores that are available through the World Data Centres and other sources overseas. Examples are SPIDR (Space Physics Interactive Data Resource) developed by NOAA and the Geophysical Center of the Russian Academy of Science [2]. SPIDR is planned to be the repository for GPS African data and a SPIDR server is installed in South Africa; other installations are planned. The African Union and the European Union have launched AMESD (African Monitoring of the Environment for Sustainable Development), an international cooperation program for implementing an efficient environmental survey system to assist the management of agriculture, ocean, and river resources. The satellite data dissemination system *GEONETCast for and by Developing Countries*, provides reliable and continuous access to environmental information and data worldwide from AMESD and other African projects.

Access to these and other basic databases, together with the associated services for analysis, visualisation, and so forth that they provide, is only possible through a good Internet connection. Without this, African scientists are denied ready access to African data.

4. eGY-Africa

eGY-Africa is a communal effort by scientists from Africa and elsewhere to promote reliable, effective, and less-expensive Internet capabilities in African universities and other research and education institutions. The role of eGY-Africa is to motivate and support African scientists by providing a focus and information source for them to be advocates at national, regional and international levels. eGY-Africa's strategy to achieve this is to (i) coordinate a network of national and international bodies and groups who share this objective, (ii) provide an information base and arguments to highlight the digital divide problem and the value of investing in a cyber-infrastructure for research and education, and (iii) influence decision-makers and providers who are in a position to take action to address the problem.

eGY-Africa is an effort to reduce the digital divide that originated during the Electronic Geophysical Year (eGY). It grew out of a combination of frustration by African scientists at the growing difficulties they face trying to participate in mainstream modern research and education, and the hypocrisy of claims that the information revolution provides unprecedented benefits to rich and poor alike. The strategies of eGY-Africa are strongly recommended by Barry [3] and Tusubira [4].

The international scientific community supports and promotes eGY-Africa through ICSU's Regional Office for Africa in Pretoria and the ICSU Committee on Data for Science and Technology (CODATA). The main sponsors of eGY-Africa are the International Union of Geodesy & Geophysics and the International Association of Geomagnetism & Aeronomy.
eGY-Africa gatherings have been held during the past 2 years in conjunction with several meetings that share a focus on ICT and Internet development in Africa. A major benefit of those meetings has been the interaction that emerged among African participants who did not initially know one another. They expressed their difficulties and vision via a set of observations and recommendations.

- Internet access in Africa is poor as a consequence of weak and restricted adoption of ICT technologies, despite multiple local, national, regional and continental initiatives.
- Internet and cyber-infrastructure in Africa needs to be at the same level as other regions of the world for the general population and, particularly, for university research and learning centres. This is fundamental for sharing information, knowledge, pedagogy, computing services, and human resources. It will also facilitate collaborations among African teams and allow them to play a role with other teams in international projects.
- High priority has to be given to improving the cyber-infrastructure for universities, colleges, and research organisations via NationalResearch and Education Networks. These NRENs should be interconnected at the regional level initially, then later at a continental level. The key words are reliability and cost-

• The performance of networks has to be monitored quantitatively. The PingER project (see below) was proposed to do this. The number of PingER monitoring stations in Africa should be extended to at least one site per African country.

• While awaiting substantial improvements in Internet services and cyber-infrastructure, African participants want to strengthen the collaboration among African teams, create African networks of excellence that in turn are connected to worldwide networks, and experiment with new technologies at least at the local level.

5. Monitoring the Digital Divide in Africa

5.1 AAU surveys

The Research and Education Network Unit of the Association of African Universities (AAU) undertakes surveys to provide an overall view of the Internet situation in African countries and in their main towns.. Precise details of Internet connectivity at the university level are seldom published, and may differ from one university to another in the same country as well as between different countries. Barry et al. [1] analyzed Internet survey results for 2007 from 21 African universities in which geoscientists are collaborating in international programmes. The best connection had 2 Mbits/s Internet access to the outside world; the worst ones were using dial up at 56kbps.

5.2 eGY-Africa Questionaire

A questionnaire survey is being undertaken by eGY-Africa, and will be further developed in collaboration with ICTP, Trieste. The purpose of the questionnaire is to assess the status of Internet and NREN services for scientists and educators in Universities and similar institutions in Africa. It also seeks information about Internet usage and access (national and institutional), what the Internet is used for, transfer rates, reliability, perceived benefits of Internet access, problems encountered, successes achieved, and recommendations. The results of the survey can be used to raise awareness among service decision-makers and to argue the case for better services. A copy of the preliminary questionnaire and results are available on the eGY-Africa website: http://www.egy.org/egyafrica.php.

5.3 PingER Project

The PingER project [5] provides active end-to-end monitoring of worldwide Internet performance going back over a decade. Measurements are made between monitoring hosts and remote hosts, using the ubiquitous ping[2] facility. The measurements include round trip time (RTT), loss, jitter, and derived throughput[3]. Currently, PingER monitors over 165 sites in 50 African countries, which contain over 98% of Africa's population. The African countries not currently monitored are Chad, Comoros, Equatorial Guinea, Sao Tome & Principe, and Western Sahara. There are monitoring hosts in Algeria, Burkina Faso, South Africa, and Zambia.

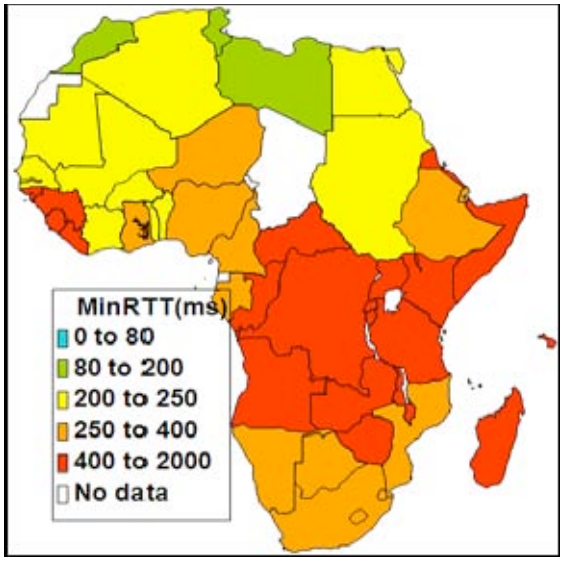

Figure 2. Minimum RTT measured from SLAC to African countries in July 2009.

A map of the minimum RTT measured in July 2009 from a monitoring host at SLAC near San Francisco to hosts in African countries is shown in Figure 2. The minimum RTT is typically seen when there is no network congestion. On long distance links, it provides an indication of the length of the path travelled between the hosts. For links connected via geo-stationary satellites, the minimum RTT is >~ 450msec (countries marked in red in Figure 2). This was particularly common for Central and Eastern African countries. The North African countries were connected to Mediterranean undersea cables. On the West coast, Angola, Benin, Cameroon, Cote d'Ivoire, Gabon, Ghana, Nigeria, and Senegal all have landing points for the SAT3/WASC/SAFE[4] undersea cable. In addition, there are inland terrestrial links to Burkina Faso, Mali, Mauritania, Niger, between Egypt and Sudan, and between South Africa and Botswana, Namibia, and Tanzania.

Transmission Control Protocol (TCP) throughput can be derived from the measured loss and RTT [6]. Since the derived TCP throughput is inversely proportional to the RTT, those countries with high RTTs (e.g., Central and East African countries) have poor TCP throughputs. Northern Africa has the best performance, followed by South Africa, Angola, Ivory Coast, Mali, and Sudan.

Figure 3 shows the average monthly derived TCP throughput by region as a function of time for the last decade. The data are measured from the USA. The data to the US and Canada are not shown, since the short RTT between the monitoring and remote hosts, due to close proximity, distorts the results. The lines are exponential fits to the data points for each region, which make the trends clearer. The orange line with dots shows a 30% improvement per year, or a factor of 10-improvement in 10 years. It can be seen that: E. Asia and Australasia have caught up with Europe; Latin America, Russia, the Middle East and S.E. Asia are catching up; S. Asia is keeping up; and Central Asia and Africa are falling further behind. Extrapolation of the current performance back in time shows that: Russia,

Latin America and the Middle East are about 5 years behind Europe; S.E. Asia is about 6 years behind; S. Asia is 9 years behind; Central Asia is 12 years behind, and Africa is 16 years behind with throughput 20 times worse than, say, Europe's. Africa's rate of improvement is about 10% per year, or a factor of 2.5 in 10 years. This compares to regions such as E. Asia, Australasia, Russia, the Middle East and S. E. Asia that are improving by 30% per year, or a factor of 10 in 10 years. Unless something dramatic happens, in 10 years time Africa's performance will be about 150 times worse than for developed regions.

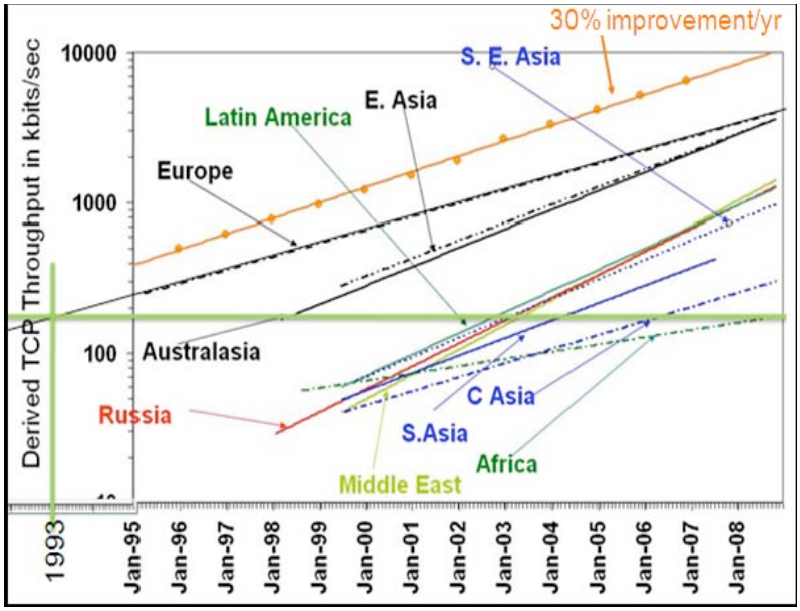

Figure 3. Derived TCP throughput for regions of the world measured from the USA. Note that the vertical scale is logarithmic.

6. Network Developments

In the past, Sub-Saharan Africa has had expensive and poor Internet connectivity with heavy use of expensive geostationary satellite connections to the outside world. In 2004, for example, African universities paid 50 times what their US counterparts paid in $/Mbps [10]. In addition, as seen above, much of the traffic between countries makes use of expensive international links via Europe and the U.S. rather than more direct connections. The main reasons behind this dire situation are lack of competition, costly technologies, and oppressive regulatory environments. These problems persist, but the over-all situation in Africa is now improving rapidly.

6.1 Cable Networks

Until July 2009, the only submarine fibre optics cable between Sub-Saharan Africa and Europe was SAT3/WASC/SAFE along the West African coast. There was no cable for the East African coast. The fibre prices in $/Mbits/s for access to this cable

Cup in South Africa rapidly approaching, many major projects are scrambling to install more submarine fibre cables serving Africa. Figure 4 shows the various cables.

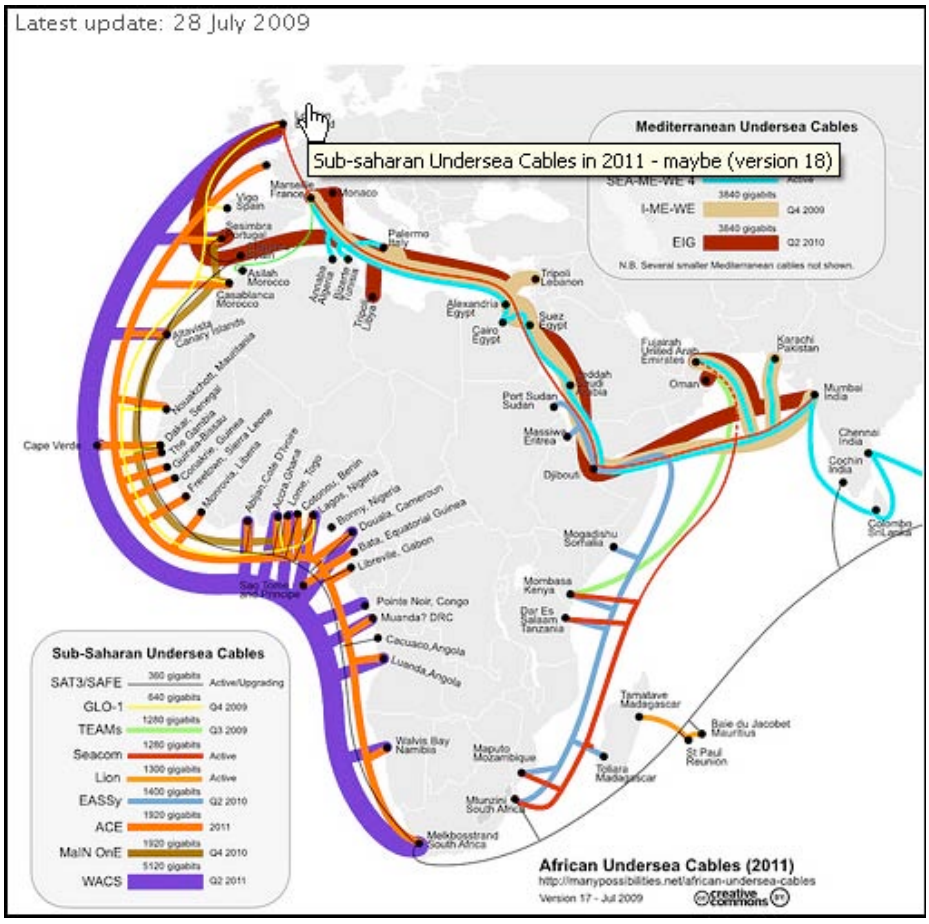

Figure 4. Submarine cable projects for Africa to be completed by 2011. The map is kept current by Steve Song and is available on the Internet together with details on the completion dates, ownership, capacity etc.

The Seacom[5] undersea fibre optics cable, connecting East Africa to the high speed Internet, went live on 23 July 2009. The cable dramatically reduces the geostationary satellite RTT of >450 ms down to 200-350ms (seen from N. America) by using shorter distance terrestrial routes. Increasing the capacity should also reduce congestion and thus losses and jitter. By providing competition, it has also already successfully reduced SAT3/WASC/SAFE prices by a factor of two [7].

At the time of writing, October 2009, by no means all hosts monitored in South Africa, Kenya, Rwanda and Uganda were connected by terrestrial links. In Kenya, five of the six hosts monitored have terrestrial connections, in Rwanda one of three, in Uganda one of three, and in South Africa the only university to be currently connected to Seacom is the Durban University of Technology. In South

Africa the rest are waiting for the development of the national SANREN6 backbone later in 2009 [8]. We anticipate that hosts in other East African countries will connect to terrestrial links. These include Zambia via Namibia[7]. In addition, in the last year, hosts such as http://www.novagest.co.ao in Angola, www.haramaya.edu.et in Ethiopia and others in Namibia have connected to a terrestrial link (in the case of Namibia passing via South Africa).

Extending the deployment of the terrestrial links to areas where fibre connections are not available (e.g., rural areas) is a challenging task. The main contenders appear to be (i) wireless -microwave, cell phone towers, WiMax, etc.,[8] (ii) Low-Earth-Orbiting Satellites[9], and (iii) weather balloons.

The presence of Internet Exchange Points (IXPs) is important since it reduces the use of intercontinental providers for connections between African countries. The PingER Project has examined the state of direct connections between African countries by measuring the trace routes within Africa in 2005 and 2009. In September 2005, most traffic from South Africa to the rest of Africa took costly international links via Europe and/or USA; only Botswana and Zimbabwe had direct routes. The situation has improved recently as direct routes from South Africa to Mozambique and Namibia were added. Similarly, connections from Burkina Faso in August 2009 were direct to only Senegal, Mali, and Benin. Most other countries were still reached by intercontinental connections via Europe, followed by many that go via Europe and N. America. Somalia was reached via Europe, N. and S. America. Burundi was reached via Europe, N. America, and E. Asia. Maps comparing routing between 2005 and 2009 as seen from South Africa are in Barton et al. [9].

6.2 NREN developments

A simple Internet search on 'NREN' reveals how rapidly they are growing as a means of meeting the high-speed Internet needs of research and education communities in countries world-wide. In order to develop NRENs, there is a need to build up bargaining power (e.g., via the Bandwidth Consortium[10]) and, thence, to sensitize and influence policy and decision makers. These needs are beginning to be met by collaboration at national, regional, continental, and international levels, and emerging movements to create NRENs in Sub-Saharan Africa [1]. Not only do NRENs provide increased bargaining power for their member institutions but also direct connections between autonomous Internet administrations that enable more direct transit of Internet traffic between countries. For example, some NRENs are peering with the GÉANT network in Europe through consortiums such as the Ubuntunet Alliance[11].

In 2007, fewer than five countries in Africa had an NREN. Those identifiable today are mapped in Figure 5 - categorized into Established (functioning), New (formally formed, but without an infrastructure in place), and Emerging (establishment is ongoing). NRENs are predominantly in Northern, Southern, and Eastern Africa. Well-established NRENs include: TENET/SAREN (South

[6] http://en.wikipedia.org/wiki/SANReN [7] http://www.itnewsafrica.com/?p=2916 [8] http://gigaom.com/2008/09/09/google-invests-in-satellite-based-internet-startup/ [9] http://www.internetevolution.com/author.asp?section_id=694&doc_id=178131& [10]

Africa), KENET (Kenya), MAREN (Malawi), EUN (Egypt), MARWAN (Morocco), RNU (Tunisia), CERIST (Algeria), and SUIN (Sudan).

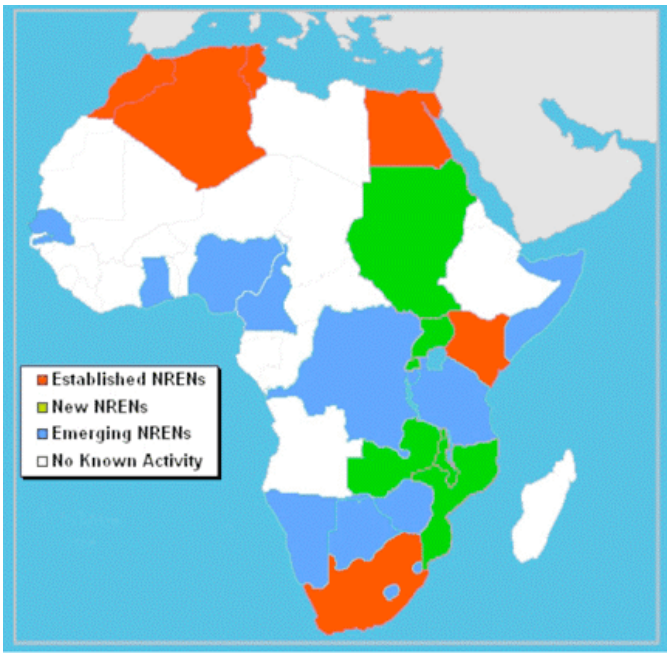

Figure 5. Map showing the state of NRENs in Africa (from Barry, 2008)

Most of the initiatives for new NRENs are from the Ubuntunet Alliance and include: Eb@le (RDC), MoRENet (Mozambique), RENU (Uganda), RwNet (Rwanda), SUIN (Sudan), and TERNET (Tanzania). Emerging initiatives are taking place in Zambia (ZAMREN); Namibia (NAMREN); Nigeria (NgREN); Ghana (GARNET); Cameroon; Senegal (RENER); and Ivory Coast.

Other regional initiatives include:

- The Africa:EUMEDConnect project funded by the European Union. This links Mediterranean African countries with Europe through GÉANT and links individual countries directly to GÉANT. EUMEDConnect is now moving to establish interconnection between the countries.
- UbuntuNet - an alliance of several Southern and Eastern African NRENs aiming to interconnect and share bandwidth. The UbuntuNet Alliance has the strong commitment of its members under difficult regulatory environments. However, with the new developments in the field of fibre infrastructure (SEACOM, TEAMS, and EASsy to come), it can be expected that regional research and educational networks will develop dramatically in East and Southern Africa in the months to come. The UbuntuNet Alliance has been connected to GÉANT since January 2008 through a 1 Gbps link from South Africa to England.
- Regional initiative for Western and Central Africa: since 2006, there is an initiative aiming at establishing a regional research and education network for West and Central Africa (WACREN). Consultations have been underway since then; a consultative meeting on the establishment of WACREN took place in Accra in November 2009, and a Task Team has been set up to develop the core documents of the initiative.
- The Nigerian backbone transmission infrastructure, developed by the MTN group and shown in Figure 6, consists of over 7,000 Km of microwave links

and fibre optics cables. The Nigerian Telecommunication company, Globacom, and another Telecommunication company, Zain, have also installed networks, in particular to connect nearly all University towns in Nigeria. The Nigerian NREN (NgREN) to be formed, can leverage the infrastructure if the service providers see synergy in partnership. Connection to other countries will be ensured by the Main-One Cable System of Main Street Technologies (the Nigerian sub-marine cable company). It will run 7000 kilometres from Portugal to Nigeria with branches to the Canary Islands, Morocco, Senegal, Ivory Coast and Ghana. The cable will deliver 1.92Tbps of bandwidth, equivalent to 10 times the available capacity of the existing fibre optics cable serving the West coast of Africa. The Main-One cable system will offer about 200 times the satellite capacity currently available across sub-Saharan Africa, and will operate on an open-access basis to telecoms, Internet, and data providers in West Africa.

Figure 6. MTN Nigeria's national microwave and fibre optics transmission network. . Red = SDH Microwave; blue = MPLS Fibre rings 1&2; purple = MPLS Fibre Ring 3; yellow = MPLS Fibre Ring 4 Source: Chukwuma et al. (2009), courtesy of MTN Nigeria

A large and growing set of organisations are enablers and supporters of the African NREN community; with new developments in terms of availability of infrastructure, new environments that see more competition, and the large policy

dialogue at national and regional levels, one can expect dramatic positive developments soon in the African research and education networking scene.

6.4 GRID developments

For many, perhaps most, scientific communities in Africa, it is easier to collaborate with northern hemisphere countries than with neighbouring African countries, even when they are in the same region, due to a lack of reliable Internet connectivity. While waiting for substantial improvements in the Internet and cyber-Infrastructure, African scientists and engineers want to learn how to deal with new technologies and to experiment with them locally. The ultimate goal is to employ technologies such as the Grid first at a national level, then at the regional level, and finally at the continental level - similar to the ones existing in Europe, Mediterranean Area, and elsewhere.

In North-Africa, Algeria, Egypt, Morocco, Syria and Tunisia participated in the European project, EUMEDGRID. A set of pilot applications of regional interest, covering archaeology, hydrology, physics, biology, engineering, robotics and cognitive sciences, and others were deployed on the EUMEDGRID infrastructure. EUMEDGRID triggered support for the creation of National Grid/e-Infrastructure initiatives in Algeria, Egypt, Morocco and Tunisia. At the end of the project, in 2008, the pilot grid infrastructure included 25 sites distributed across 13 countries, with all relevant grid services up and running.

In 2006, UNESCO and Hewlett-Packard launched an ICT-based project to counter the brain drain in Africa. This project involves five universities, located in Algeria, Ghana, Nigeria, Senegal and Zimbabwe. Working in collaboration with teams from the European Grid project, EGEE, computing centres were equipped, training was conducted on machine (cluster) management, and a local Grid implemented. In Senegal, the Cheikh Anta DIOP University in Dakar has been connected since 2007 to the European Grid network via the EGEE project. In South Africa, two schools on Grid were held with the participants from different African countries. A Grid called SAGRID is in preparation. In the Democratic Republic of Congo, the University of Kinshasa has started making tests on the Grid.

9. Cooperation and Partnerships

Many initiatives from local, governmental, and international organisations promote, survey, and fund networking in Africa. Organizations, such as the International Telecommunications Union, UNESCO, the European Commission (EC), and the International Development Research Centre play a role in the deployment of ICT in Africa and promoting African research and education networking.

The European Commission has two ‘Support Actions’ for ICT Research Engagement in Africa: IST-Africa with partners in 14 African countries and a cooperative forum on ICT research called EuroAfriCa-ICT[12]. During 2008 - 2009 IST-Africa organised 17 Training workshops in Botswana, Kenya, Lesotho, Mozambique, Namibia, South Africa, Tanzania, Uganda, Rwanda, Burundi and Mauritius. IST-Africa has helped African research organisations participate in proposals submitted under FP7, ACP-ICT and ACP-ST Calls. Since 2007,

EuroAfrica has organized 13 “Awareness” workshops in Sub-Saharan Africa, and workshops in Brussels in March 2009 and Addis Ababa in February 2010.
In 2007, the African Union Commission and the European Commission launched six lighthouse projects in the framework EU-AU Partnership for Science, Information Society and Space. Among those identified as “early deliverables” was “AfricaConnect”, a project aiming at extending the European research and education high-speed network GÉANT to Sub-Saharan Africa. Subsequently, in 2009, the European Commission awarded a contract to a consortium led by the Swedish Royal Institute of Technology (KTH) to carry out a feasibility study for AfricaConnect (FEAST[13]). Since then, the FEAST team has produced a roadmap for AfricaConnect, with recommendations for the implementation of the project. Another important AU-EU Partnership project is the African Internet Exchange System (AXIS) to support the establishment of a continental African internet infrastructure through national and regional internet exchange points. This is considered crucial for the development of the Internet in Africa, generating huge costs savings by keeping local traffic local and offering better quality of service and new applications opportunities.

eGY-Africa has started to engage with bodies concerned about the digital divide issue, with the aim of raising awareness and promoting cooperation. Examples include the following.

The African Geospace Society – AGS is a newly formed Earth and space science society set up by African scientists as a counterpart to the American Geophysical Union (AGU), the European Geosciences Union (EGU), and the Asia Oceania Geosciences Society (AOGS).

International Geophysical Research Group Europe- Africa – IGRGEA grew out of the International Equatorial Electrojet Year IEEY effort in Africa in 1992. It comprises a network of scientists from different countries mainly working now on integrated studies of electrodynamics and magnetic phenomena in the Sun-Earth System [11]. The IGRGEA network of scientists constitutes a user community to support and promote the deployment of the Internet and new ICT technologies that are required to develop their scientific work. The IGRGEA contributes to the International Space Weather Initiative (ISWI).

The International Heliophysical Year and *the International Space Weather Initiative* - IHY has been successful in promoted the participation by developing nations, particularly in Africa, in international global studies of the Sun-Earth System. It was based on the deployment of instruments, observational programs, and education [12] [13]. IHY’s successor, ISWI is continuing this tradition and the popular series of workshops in Africa and other developing countries.

The African Monsoon Multi-disciplinary Analysis - AMMA is coordinated by MeteoFrance, and involves many partners from Europe, Africa, and America. The data concerning weather and climate are the core of the project. The poor performance of the Internet and its high cost have been obstacles for achieving real-time transfer of all the data within Africa and from Africa to Europe.

Geoscience Information in Africa[14] - GIRAF is an initiative for promoting geoscience information usage across Africa in an ICT-aware manner. Support comes from the International Union of Geological Sciences and Germany. A prime objective is to set up a pan-African network for exchanging knowledge about geoscience information to make Africa a more active part of the international geoscience information community. A successful workshop was held in Namibia in 2009 and another is planned for Tanzania 2011 [14].

The Inter-Academies Panel on International Issues – IAP is a global network of 98 science academies designed to help its members develop the tools that they need to participate in science policy discussions and provide input to policy makers at the national and international levels. Many IAP members are in developing countries. IAP runs programs that address directly the Internet connectivity and digital divide issue in developing countries.

CODATA - an ICSU Committee that works to improve the quality, reliability, management, and accessibility world-wide of data of importance to all fields of science and technology. Two task groups have interests relating to eGY-Africa: the task group on *Preservation of and Access to Scientific and Technical Data In Developing Countries* and the the task group on *Data Sources for Sustainable Development in South African Development Community Countries.* Both are partners in eGY-Africa.

11. Conclusion

Research and education are essential ingredients for national advancement worldwide. Countries that invest in research and education are conspicuously more successful in the long-term than those that don't. As we move into the modern information era, this translates into a need for ready and effective access to the Internet and information highways by those engaged in research and education. Countries in Africa, as in other parts of the world, recognise this reality and are developing cyber-information networks (NRENs) to meet the information and service delivery needs of their research and education sectors. But, as the PinGER project and other surveys of capability demonstrate, African countries, in general, have poorer Internet connectivity and have been advancing more slowly than in other parts of the world – the digital divide for Africa has been growing. Cybercafés often have better Internet connectivity than the neighbouring university, and scientists who wish to interact with the global research and education community are obliged to pay high personal costs.

The recent expansion of fibre-optic infrastructure in and around Africa holds out the very real prospect of eliminating the digital divide. In the words of the FEAST reports (www.feast-project.org),

> "Development in Africa is increasingly dynamic, not least due to several new infrastructure initiatives materializing, including the communication infrastructure. Africa is about to become the best interconnected continent in the world via several submarine cable projects starting operations 2009-2011. Although it will still take time to get a dense terrestrial fibre grid providing back-hauls, all major hubs seem now to be connected and most African countries can accelerate their development towards knowledge societies as its foundation, an open access information and

businesses and as citizens."

The FEAST recommendations continue by addressing political issues: "….. The main challenges include political awareness about the nature and importance of dedicated research an education networks as well as the necessity and will to accelerate the transformation of the communication market making communication infrastructure an affordable utility. The [FEAST] recommendations are to immediately support the ready communities to acquire links to build their networks, to strengthen the capacity in terms of educated and trained human resources both in the ready communities and in the emerging communities, and to high-light applications demonstrating the return on investment and motivating a second phase supporting the emerging communities."

eGY-Africa is contributing to this effort by mobilising opinion in Africa and internationally, accumulating information that can be used to argue the case for investing in Internet and NREN capability, and bringing together different groups in Africa and elsewhere that share the goal of reducing this digital divide.

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Glossary and links

AAU	Association of African Universities	http://www.aau.org
ACBF	African Capacity Building Foundation	http://www.acbf-pact.org
ACMAD	African Centre of Meteorological Applications for Development	http://www.acmad.ne
AfNOG	Forum for the exchange of technical information. It aims to promote discussion of implementation issues that need community cooperation.	http:// http://www.afnog.org
AfriNIC	Regional Internet Registry that will allocates IP and AS numbers in the African region	www.afrinic.net
AGS	African Geospace Society	http://www.arcsstee.org/ags.html
AGU	The American Geophysical Union	http://www.agu.org
AMCOST	African Ministerial Council on Science and Technology	http://www.nepadst.org/
AMESD	African Monitoring of the Environment for Sustainable Development	http://www.amesd.org/
AMMA	African Monsoon multi-disciplinary Analysis	http://www.amma-eu.org
ARAPKE	African Regional Action Plan on the Knowledge Economy	
AOGS	Asia Oceania Geosciences Society	http://www.asiaoceania.org
AU	African Union	http://www.africa-union.org
AXIS	African Internet Exchange System	
AUC	African Union Commission	http://www.africa-union.org
CERIST	Established NREN in Egypt	
CODATA	Committee on Data For Science And Technology (ICSU)	http://www.codata.org/
CRASA	Communicators Reguators' Association of Southern Africa	http://www.crasa.org
DANTE	Delivery of Advanced Network Technology to Europe	http://www.dante.net
DFN	Plans builds and operates advanced Research & Education networks	http://www.dfn.de
Eb@le	New NREN proposed for DRC	
ECOWAS	Economic Community of West African States	http://www.ecowas.iint
EGEE	Enabling Grids for E-SciencE	http://www.eu-egee.org
EGU	European Geosciences Union	http://www.egu.eu/
eGY	The Electronic Geophysical Year, 2007-2008;	http://www.egy.org
eGY-Africa	eGY initiative for better Internet access for research & education	http://www.egy.org/egyafrica.php
EU	European Union	http://europa.eu
EUMEDGRID	Empowering eScience across the Mediterranean	http://www.eumedgrid.org
EUN	Established NREN in Egypt	http://www.eun.eg
GARNET	Emerging NREN initiative in Ghana	http://www.garnet.edu.gh
GARR	The Italian Academic and Research Network	http://www.garr.it
GCRAS	Geophysical Center of the Russian Academy of Science	
GÉANT	The fast and reliable communication infrastructure dedicated to serving Europe's research and education community	http://www.geant.net
GEONETCast	A near real time, global network of satellite-based data dissemination systems	http://wiki.geonetcast.org/
GIRAF	Geoscience Information in Africa	http://www.GIRAF2009.org
GPS	Global Positioning System	
IAP	Inter-Academy Panel on International Issues	http://www.iap.org
ICDC	Inter-Divisional Commission on Developing Countries	
ICSU	The International Council for Science	http://www.icsu.org
ICT	Information and Communication Technology	
ICTP	International Centre for Theoretical Physics	http://www.ictp.trieste.it/
IDRC	International Development Research Centre	http://www.idrc.ca
IEEE	IEEE	http://www.ieee.org/portal/site
IGRGEA	International Geophysical Research Group Europe-Africa	
IHY	International Heliophysical Year	http://www.Ihy2007.org
IUGS	International Union of Geological Sciences	http://www.iugs.org
KENET	Established NREN in Kenya	http://www.kenet.or.ke
MAREN	Established NREN in Malawi	http://www.malico.mw/maren/
MARWAN	Established NREN in Egypt	http://www.marwan.net/
MoRENet	New NREN proposed for Mozambique	
NEPAD	New Partnership for Africa's Development	http://www.nepad.org
NgREN	Emerging NREN initiative in Nigeria	
NOAA	National Oceanic and Atmospheric Administration	http://www.noaa.gov
NREN	Research and Education Network	
NSRC	Network Startup Resource Center	http://www.nsrc.org
PAREN	Promoting African Research and Education Networking	
RENATER	French National Network of telecommunications for the technology, the education and the Research	http://www.renater.fr

RENER	Emerging NREN initiative in Senegal	
RENU	New NREN proposed for Uganda	
RNU	Established NREN in Egypt	
RTT	Round Trip Time (for PinGER)	
RwNet	New NREN in Rwanda	
SADC	Southern African Development Community	http://www.sadc.int/
SPIDR	Space Physics Interactive Data Resource	http://spidr.ngdc.noaa.gov/spidr/
SUIN	New NREN in Sudan	
TCP	Transmission Control Protocol	
TENET/SANREN	Established NREN in South Africa	http://en.wikipedia.org/wiki/SANReN
TERNET	New NREN in Tanzania	http://www.ternet.or.tz/
URSI	The International Union of Radio Sciences	http://www.ursi.org
WATRA	West Africa Telecommunications Regulators Assembly	http://98.130.227.12/Index.aspx
ZAMREN	Emerging NREN initiative in Zambia	