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Internet Performance to Africa

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Abstract

We report the first results ever for real-time Internet performance to Africa using the PingER methodology. Multiple monitoring hosts were used to enable comparisons with performance from different parts of the world. From these preliminary measurements, we have found that Internet packet losses to some African sites in recent months range from very poor to bad (> 12%), some getting better, others are holding steady or getting worse. This, together with the average monthly Round Trip Times, imply end-to-end maximum TCP throughputs that are order of magnitudes different between countries in the region. Africa is shown to be far from the Internet performance in industrialized nations due to the poor infrastructure in place today. These monitoring efforts can provide valuable information to analyse the relative rates of future improvement and today they help us to quantify the digital divide and can provide quantitative information to policy makers.

Introduction

Connectivity in some Southern regions is in an early stage. In particular, sub-Saharan Africa has yet to make the kind of progress in science, technology and economy that has already been achieved in the more dynamic areas of growth in the South [1]. The limited bandwidth of the few available telecommunication lines in countries that are joining the Internet cause line congestion and make access exceedingly slow, often beyond the limit of usability. Even more importantly, there remains the lack of adequate infrastructure and computers in remote regions [2,3].

These problems reduce drastically the effectiveness of the Internet as a working and communication tool, and delay the creation of South-South collaboration and development, considering that about 70-80% of the people in Africa live in rural areas in isolation.

The transfer of voice and data (Web, FAX, e-mail, etc) using VSAT technologies is proving to be a realistic solution. For example, at NITDA in Nigeria [4], satellite connection is offered to serve the Capital's main offices, as well as Mobile Internet Units (MIU). This is part of a development project on computer-mediated education for school teachers and students in rural and urban marginalized communities [5]. To overcome insufficient or non existing basic telecommunication services in the region, computer networks powered by solar panels or renewable energy [6] are also growing, since there exists a large demand to communicate and improve healthcare and sustainable development.

Following the proposal on real-time network monitoring in Africa discussed at the Open Round Table carried out in 2002 in Trieste [7], efforts have been made to quantify the digital divide realities in Africa. The motivation to carry out this actual monitoring of the African Internet performance is to help to create further awareness of the lack of infrastructure and facilities. This monitoring is also essential to enable “Virtual Laboratories”, to catalogue and understand critical needs, set expectations, provide trouble shooting abilities, and to allocate resources to optimize/improve performance. In turn this will imply a better distribution of money resources. This is discussed in this paper, where we report the first results ever for Internet performance in Africa.

Methodology/setup

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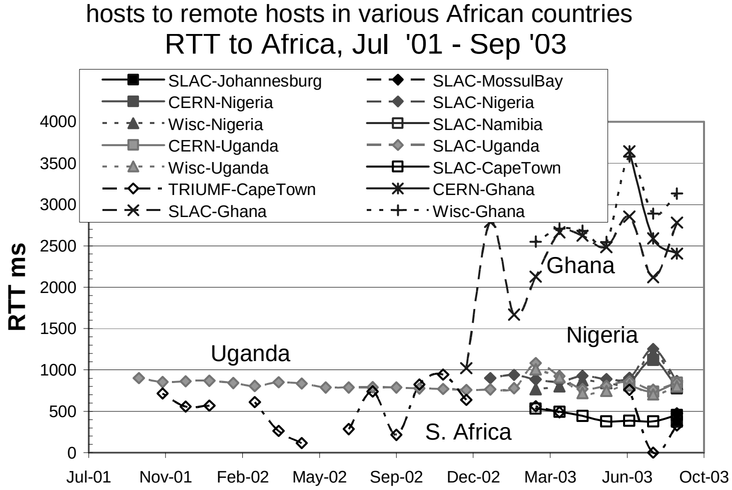
The methodology employed by PingER is described in a companion paper [8]. For the results in this paper, we utilized monitoring hosts at CERN in Geneva Switzerland, SLAC near San Francisco California, TRIUMF in Vancouver Canada, and the University of Wisconsin in Madison Wisconsin. The use of multiple monitoring hosts enabled us to ensure there were no pathologies associated with a given monitoring host and also to enable comparisons with performance from different parts of the world.

As a direct response to the one recommendation specific to monitoring made at the 2002 Round Table held at Trieste, the Abdus Salam ICTP's electronic Journals Delivery Service (eJDS) signed early 2003 a Memorandum of Understanding (MOU) with the Stanford Linear Accelerator Center's (SLAC) PingER project. The primary purpose of this MOU was to utilise the eJDS network for monitoring real-time connectivity patterns among research and educational institutions in developing countries. The recommendation explicitly stated: "To devote resources to monitor in real time the connectivity of research and educational institutions in developing countries and to encourage (and devote resources to) the development of the connectivity". Since then, the PingER/eJDS project started to monitor sites world wide.

To obtain remote hosts to monitor at remote sites in Africa, we found contacts at the sites by sending emails to colleagues especially in the International Committee for Future Accelerators (ICFA) and the eJDS [9]. All of these groups are actively working on trying to bridge the Digital Divide gap and so were most helpful. Once we had potential contacts we sent email to them explaining our purpose, our needs, and the possible impact on the network and hosts at the site. Sometimes these emails resulted in further referrals, and/or required extended explanations. Once we had a host to monitor, we then checked that the host was accessible to pings and then entered it into the relevant PingER databases. Typically about 75% of the contacts eventually resulted in a remote host to monitor successfully. Sometimes it took many months to conclude agreements. In some cases pings were blocked and were outside the control of the remote site personnel (e.g. if a service provider blocked the pings).

Currently we monitor hosts in: the Biotechnology and Nuclear Agric. Research Institute of the Ghana Atomic Energy Commission in Accra Ghana, Obafemo Awolowo University in Ife-Ife Nigeria, Makrere University of Kampala Uganda, and Schoolnet in Windhoek Namibia, the University of Cape Town S. Africa, Mussel Bay South Africa and Johannesburg S. Africa. All the hosts, apart from the last two are at Academic and Research (A&R) sites. The last two are commercial sites that we obtained through TomWare.

Figure 1: RTTs from N. America and European monitoring hosts to remote hosts in various African countries



Results

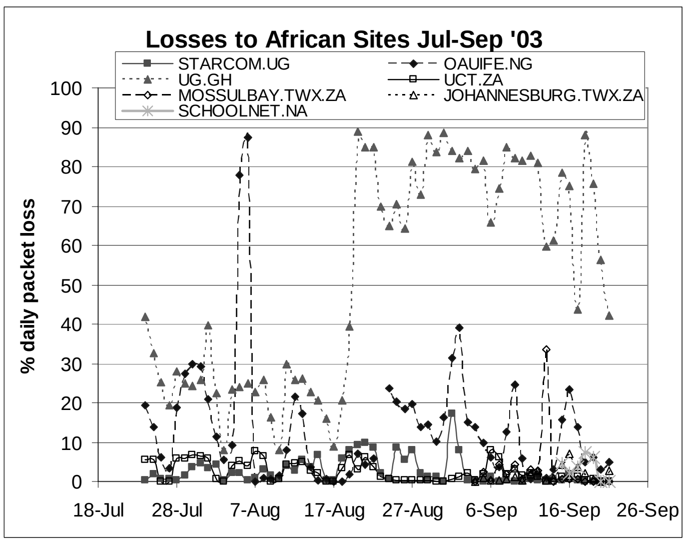
We used `traceroute` to find the routes from SLAC to the remote hosts. The route to: Ghana used UUNET and Satworks as the carriers; Namibia used UUNET and xantic; Nigeria used TELIANET and New Skies; Uganda used Level(3) and globalconnex; and South Africa used C&W and

Telkom S. Africa (Mossul Bay), UUNET and Internet Africa (Johannesburg), and CAIS and Telkom S. Africa (University of Cape Town).

The average monthly Round Trip Times (RTT) to the various remote hosts in Africa from the monitoring sites in N. America and Europe are shown in Fig. 1. It is seen that for a given remote host there is little difference between the monitoring sites. This may indicate that the common bottleneck in most cases is closely associated with the remote site. It is also seen that the routes to Ghana, Nigeria and Uganda have RTTs of over 600ms. and thus probably include a satellite hop.

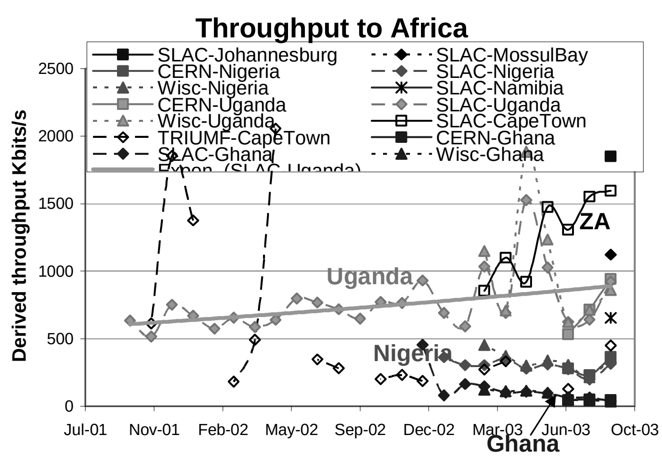
The losses averaged over a day from SLAC to various remote hosts in Africa are seen in Fig.2 from the middle of July 2003 to the middle of September 2003. A noticeable step change in the losses to Ghana is seen starting around August 18. This does not appear to be due to ping rate limiting. The effects appear to vary from hour to hour, though there does not appear to be a strong diurnal pattern. The losses occur on the last two hops in Ghana. This is currently under investigation. Following this step change losses to Ghana are terrible making the link almost unusable. Losses to Nigeria although better are still categorized as bad (> 12%) most of the time. Uganda, Namibia and South Africa on the other hand have monthly average losses of between 1 and 3% (acceptable to poor).

Figure 2: Losses from SLAC to African countries Jul-Sep 2003



Combining the losses and RTTs using the Mathis formula for deriving the maximum TCP throughput [10], i.e. *Derived throughput ~ MSS/(RTT*sqrt(loss))* and plotting the monthly averages from July though September 2003 for monitoring hosts in N. America and Europe to hosts in Africa yields Fig. 3. It can be seen that derived throughput is best to S. Africa, followed by Uganda and Nigeria with Ghana the lowest. There is over an order of magnitude difference between S. Africa and Ghana. The derived throughput for Nigeria is close to that of broadband DSL and cable to the home in the U.S., and for Ghana the derived throughput is close to that for a dial up modem. The solid line through the Uganda points is a fit to an exponential to help guide the eye. It appears that the performance for

Figure 1: Derived throughput from N. America and Europe to some African countries



Cape Town and Uganda is improving while Ghana and Nigeria are holding steady or getting worse. There is insufficient data for Namibia to detect trends.

Conclusions

Much work needs to be done to extend the monitoring to more of Africa. Even for the countries already monitored, more sites are needed to help avoid anomalous results associated with a single site. Unfortunately it often appears that with all the other challenges in the region, Internet monitoring may not be very high on peoples' agendas. The authors encourage readers to provide contacts for new countries and sites.

From the existing results, it is apparent that Ghana in particular and Nigeria have poor to bad connectivity (the former is almost unusable), in fact the sites appear to have less throughput than many homes with DSL or dial-up modems in developed countries. Even within Africa, there are more than an order of magnitude differences in performance between different countries. Of even greater concern is the lack of improvement with time for both Ghana and Nigeria. Comparing the performance to Africa with other regions of the world [11], Africa has the poorest Internet performance, the performance is a factor of 30 below that of say Europe, even Uganda (one of the better performing African countries) is at the same state Europe was at in 1995, and the trends show it is falling behind other regions.

There is considerable diversity of routes and providers even for different sites in a single country such as S. Africa. This compares unfavorably to S. America or the Caucasus and Central Asia where AMPATH [12] and the Virtual Silk Highway [13] are successfully coordinating and providing much better connectivity for several countries in the regions. Hopefully the Africa ONE project [14], an undersea fiber-optic cable system to link the countries of Africa to one another and to the world will enable improved connections at reduced cost.

Acknowledgements

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