Chapter 6

THE PERSISTENT BANDWIDTH DIVIDE IN AFRICA: FINDINGS OF THE AFRICAN TERTIARY INSTITUTION CONNECTIVITY STUDY AND LESSONS FOR DEVELOPING KNOWLEDGE INFRASTRUCTURE AND NETWORKS IN AFRICA

by
Robert Hawkins
World Bank

In the knowledge economy, universities around the world are being looked upon to take an increasingly greater role in producing the human resources necessary to help their countries become more competitive globally. Universities face the challenge of preparing the next generation of leaders with the requisite skills to create value and contribute to their societies. Universities also support the academics who are conducting the cutting edge research that will generate the new ideas to propel development. To facilitate this learning, universities also must provide the requisite infrastructure for their students, professors and researchers to engage in research and the development of new knowledge that will keep them at the forefront of innovation.

The Internet continues to be an essential tool for universities to engage in this research and development that is being demanded of them. As collaboration lies at the heart of research, academics and researchers use the network for a myriad of purposes. Every day university students and faculty use the Internet to search for information, to collaborate with colleagues around the world, to access remote laboratories for experiments in chemical engineering or microelectronics for instance, and even to log into radio telescopes to view the stars. As more of these applications and tools become accessible over the Internet, the speed and capacity of the pipes connecting universities together become increasingly important.

Looking back over the history of the Internet, universities have always played a central role in its development. After the Defense Advanced Research Projects Agency (DARPA) developed the ARPANET as the first prototype of the Internet, the next stage of development and popularisation of the Internet took off at the universities. The first ARPANET connections for instance took place between UCLA, the Stanford Research Institute, University of California Santa Barbara, and the University of Utah. By 1970, MIT and Harvard joined the network, followed soon thereafter by Carnegie-Mellon, Case-Western Reserve, University of Illinois and many others.

Similarly, in Africa the first wave of development of the Internet occurred at the universities. Unlike the US and Europe however, African universities did not connect to each other but rather to the existing backbone developed outside the continent. The poor state of telecommunications infrastructure, existing monopolies and unfavourable regulatory regimes can account for much of this slow pace in development, but more than ten years

later, African universities still lag far behind counterparts in the rest of the world with regard to Internet connectivity.

In June 2004, the World Bank commissioned a study, "The African Tertiary Institution Connectivity Study (ATICS)" to try to learn more about the current state of African university connectivity. Between August and November 2004, consultants surveyed 83 institutions of higher education in 40 countries across the continent. The objectives of the study were to assess:

- The types of connectivity, bandwidth capacity and costs currently existing at tertiary institutions.
- The existing types of Internet service providers servicing the universities.
- The use of VSAT technologies as the primary choice for connectivity and the various licensing agreements to use the technology.
- The levels of computer infrastructure at the various institutions.
- The degree to which bandwidth is monitored and managed by the network managers.
- The extent to which new ICT initiatives were being planned as well as the degree to which e-learning is being employed at the institutions.

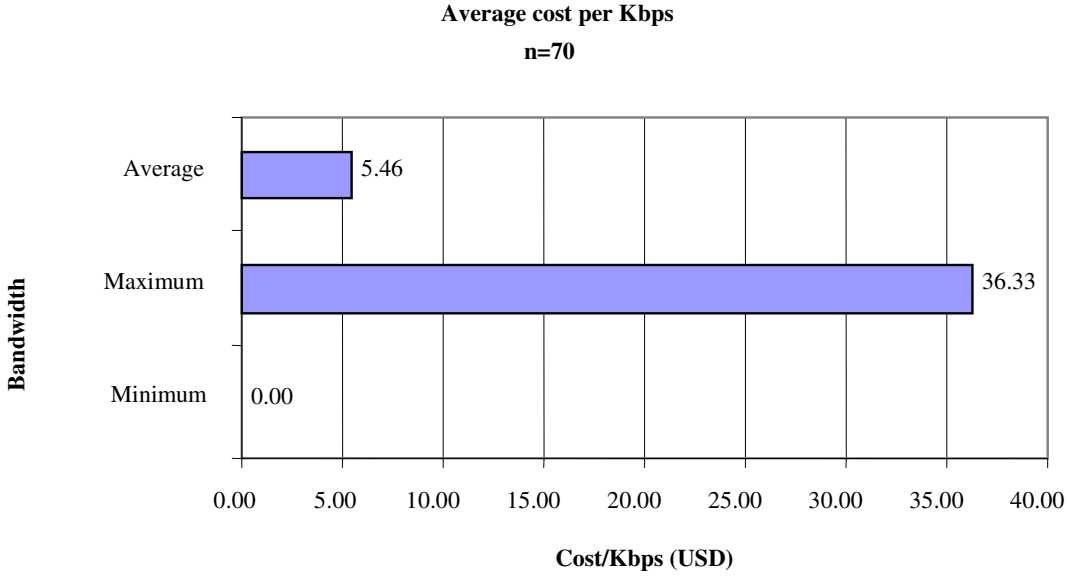
Bandwidth availability

The first finding of the study reveals that the average university in Africa has no more bandwidth than the amount found in a residential connection in Europe or the United States. In the study, the average reported bandwidth for the sample was 537 Kbps up and 769 Kbps down. Needless to say that this quantity of bandwidth serves an academic community of tens of thousands as opposed to the mother, father and 2.2 children found in your average US or European residential home. With this limited amount of bandwidth, the study also shows that university networks are used at almost full capacity with large demand for the scarce connectivity at most institutions. For instance, the average percentage of time where links were at 100% capacity is over 60% of the time which is an extremely high figure given that the measurement covers a 24 hour time period every day of the month.

Bandwidth cost

The study reveals that African universities are paying exorbitant costs for their limited bandwidth. On average, African tertiary institutions pay USD 5.46 per Kbps/month, which is roughly the equivalent of 50 times what a typical US university would pay for the same quantity of bandwidth. Analysing regional disparities shows that institutions from West Africa pay the highest amount or about USD 8 per Kbps/month while institutions in North Africa pay the least at USD 0.52 per Kbps/month. The main cause for this disparity in cost is that the North African universities have access to reasonably priced fibre connectivity in the Mediterranean and have also formed a consortium (EUMED Connect) to pool demand and negotiate favourable terms for access to this fibre.

Figure 6.1.



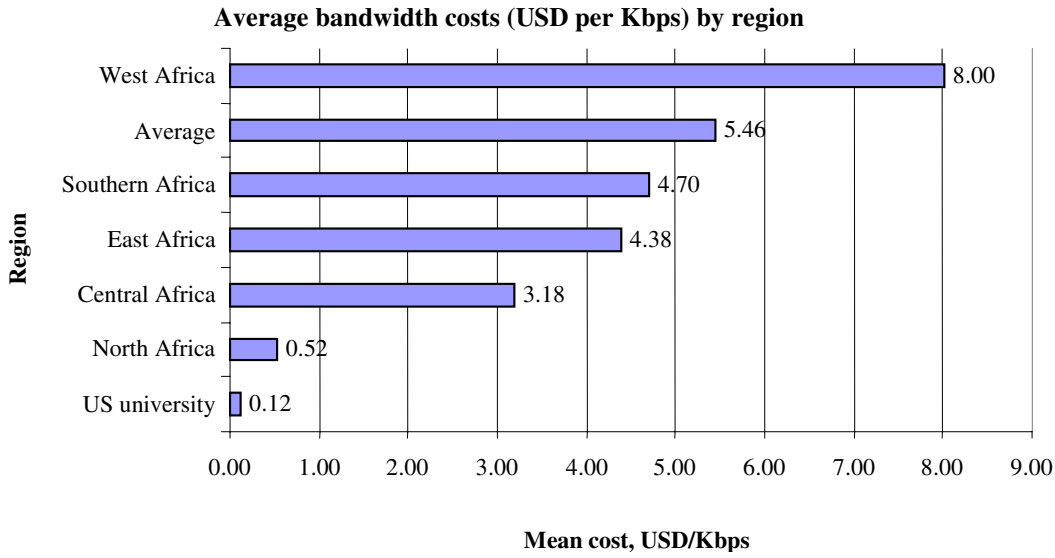
Source: ATICS 2004 *(www.atics.info)*.

The study also reveals huge disparities within countries with regard to costs of connectivity. For instance, in Botswana, the Botswana College of Agriculture, while being part of the University of Botswana, pays a significantly higher amount for connectivity to the exact same Internet provider – the Botswana Telecommunications Corporation. The University of Botswana pays this provider USD 17 000 for a 1Mb/4Mb wire connection or about USD 3.32 per Kbps/month while the Botswana College of Agriculture pays USD 4 000 for a 128kps wire connection or about USD 15.63 per Kbps/month.

Also, VSAT costs on average tend to be more expensive than land-based connections. Land-based connectivity however ultimately gets access to the international Internet through VSAT and provides much lower levels of quality than the VSAT connections.

The study clearly supports the premise that the greater the volume of bandwidth purchased, the lower the marginal cost that is paid. This finding supports further development of consortia of universities such as the EUMED connect consortium formed in North Africa to aggregate demand and obtain lower costs for all institutions.

Figure 6.2.



Source: ATICS 2004 *(www.atics.info).*

Bandwidth quality

Most of the institutions surveyed (66%) report that they either did not have a committed information rate (CIR) from their provider or did not know what it was. The CIR is a guarantee of a certain amount of bandwidth to the Internet at all times as opposed to sharing a connection with other users which will result in lower throughput when there is a large amount of demand on the provider's connection. The survey also reveals that where the respondent does not know if they have a CIR, they are also paying the most for their bandwidth – resulting in both high costs and low quality. This last point reveals the power of knowledge and information in negotiating for bandwidth quantities and costs.

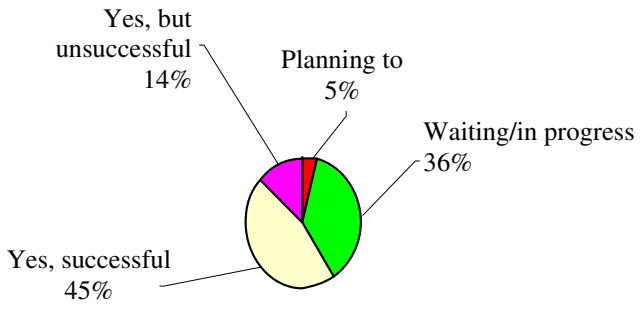
The regulatory environment

The study also investigates the environment under which universities obtain VSAT connectivity. By polling the end users, the study aimed to get a more candid assessment of the regulatory reality in each country. The study shows that only 14 of 52 countries have clearly defined competitive satellite regimes. In this environment, more than half of the universities sampled (55%) had not been able to get a proper VSAT license. However, a majority (58%) of those universities which did own a VSAT, were able to obtain free licenses usually through a waiver as an educational institution. That being said, the average cost of those who did pay for the license was USD 13 553, which is far higher than the EU average of USD 426.

Figure 6.3.

Attempts to obtain VSAT licenses

n=36



Source: ATICS 2004 *(www.atics.info).*

Computer infrastructure

The survey also examines computer penetration at universities to determine the extent to which bandwidth could potentially be utilised. The survey shows large differences in the levels of computer access among the various institutions. For instance, the highest number of users per computer is 929, while the average across the sample is 55. This figure is still more than 10 times the average at US institutions which have about five users per computer.

The study also examined the level of bandwidth per networked computer. The Sudan University of Science and Technology has the lowest level of connectivity per computer with a miniscule 0.32 kbps average compared with the highest figure of about 37 kbps at the Universite de Bangui which is roughly the equivalent of a dial-up modem connection. It must be noted that the high rate of connectivity per computer in many of the institutions reflects a very low number of computers relative to bandwidth and not necessarily an optimal configuration of computers and connectivity. The average figure across the sample was 3.36 kbps.

Table 6.1. Rankings: Bits per networked computer

University	Country	Bits per networked computer
Top 10 universities		
Université de Bangui	Central African Republic	36 571
Université Catholique de Bukavu	DRC	15 360
University of Hargeisa	Somaliland	10 667
Université du Sahel	Senegal	10 240
Ashesi University	Ghana	10 105
University of Yaoundé II	Cameroon	9 600
Univeristé Libre de Tunis	Tunisia	9 600
Njala University College, University of Sierra Leone	Sierra Leone	8 000
Open University of Sudan	Sudan	7 680
African School of Architecture and Town Planning (West and Central Africa)	Togo	7 467
Bottom 10 universities		
Sokoine University of Agriculture	Tanzania	692
Moi University	Kenya	640
University of Port Elizabeth	South Africa	620
Gondar University	Ethiopia	533
University of Asmara	Eritrea	512
Egerton University	Kenya	512
Université du Benin	Togo	366
Eduardo Mondhlane University	Mozambique	346
University of Zambia	Zambia	320
Sudan University of Science and Technology	Sudan	320

Source: ATICS 2004 *(www.atics.info)*.

Bandwidth management

Bandwidth management represents a major area where quick improvements through skills training can be made to improve the cost and quality of university bandwidth in Africa. The majority of the respondents surveyed (59%) report that they do not practice bandwidth management or seldom do. Moreover, while 41% of the respondents indicated that they do monitor bandwidth, only five of the universities could provide basic usage figures such as average bandwidth used which reveals sporadic monitoring at best. In evaluating the manpower needed to monitor and maintain a university network, it is also interesting to note that the survey reveals that VSATs have a higher failure rate with 10.63 hours per month down time than other type of links. Fibre for instance has the lowest rate of failure the only 0.15 hours per month reported.

Policies and strategies

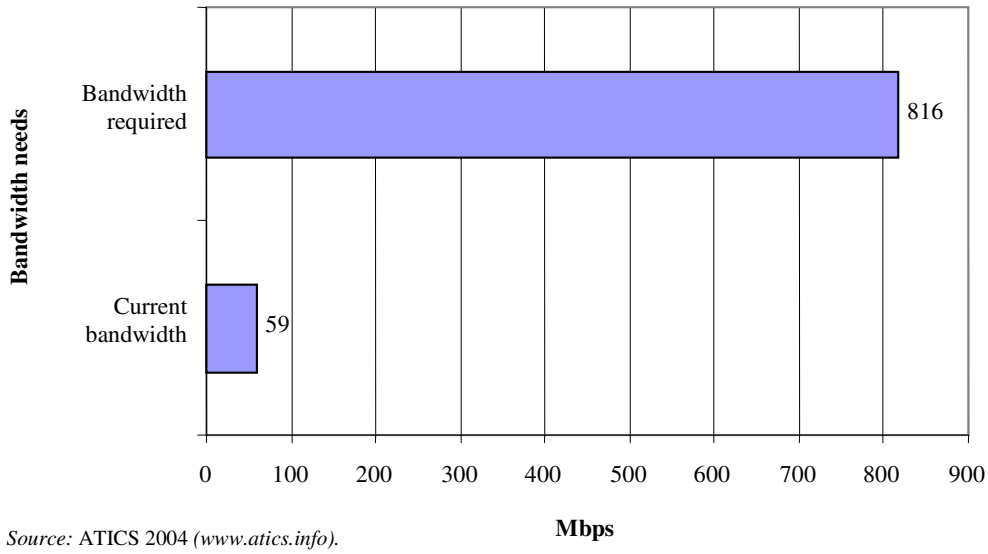
Most universities have not clearly articulated good strategic plans for use of their Internet connectivity. The survey illustrates that while 45% of universities have written an e-learning or ICT strategy for use of broadband connectivity, an almost equal amount or 42% have not. Also clearly lacking among African universities is a collaborative peering strategy with other institutions. Only eight countries in Africa currently have National Educational and Research Networks (NRENs) and only 22% of the institutions surveyed are members of these networks. While US universities are enjoying high speed connectivity at low costs through the collaborative Internet II consortium and European institutions have banded together to form GEANT, most African institutions remain isolated from one another.

Bandwidth requirements

Based on a formula[1] derived by the Partnership for Higher Education, an estimated bandwidth requirement was determined for African universities based on the number of available computers at an institution and an assumption that each computer handles around ten individuals per day. The calculation also estimates that each user would want to download around ten Mb of information per day with information defined as journal articles as opposed to more intensive information sources. With these assumptions, the survey compared current bandwidth with estimated requirements for 73 universities. The outcome calculates that average bandwidth requirements are at least ten times the current usage. This amount of additional bandwidth represents roughly the capacity of five to ten transponders if a VSAT solution were put in place.

Figure 6.4.

Estimated total bandwidth requirements
n=73



Source: ATICS 2004 *(www.atics.info).*

1. 10Mb/day * 8 bits *10 people * No. of networked computers ÷ seconds in 10hrs = Mbps required.

Recommendations

A number of recommendations emerged from this study for improving bandwidth quality, quantity and cost at African universities. The first recommendation is that universities in Africa need to do more to collaborate and form bandwidth buying consortia. It makes no sense for each university to negotiate its own bandwidth deals particularly as marginal costs decrease as volume increases. The study estimated that through the formation of consortia and the pooling of their demand, African universities could halve the cost of their Internet connectivity. Moreover, the formation of consortia could translate into other services where economies of scale could be exploited. For instance, subscriptions to journals available through digital libraries represent an area where one library servicing a large number of universities makes more sense than each university creating their own. The same logic applies to learning management systems and also to other forms of electronic content such as open courseware and learning objects. In order to define these benefits however, universities also need to develop clear policies and strategies for use and development of their Internet infrastuctrure.

As a first effort to address the high costs of connectivity in Africa, any new consortium of universities should also lobby for a more favourable regulatory environment for enhanced connectivity. This may take the form of waivers for VSAT licenses, concessionary pricing for access to fibre networks, clarity with regard to use of VOIP (voice over Internet protocol) or wireless spread spectrum licensing for connecting disparate campuses.

This form of collaboration could also lead to greater aggregation of expertise across African universities. Facilitating a means for the best African academics to collaborate to create African courses and content to be delivered to the rest of the world is a vision that should be embraced. Connectivity would foster the best minds in Africa to exchange ideas, data and solutions to Africa's challenges. From a practical perspective the aggregation of talent to manage the networks of a number of universities through centralised network management would allow for scarce talent to serve the greatest numbers. Moreover, the collaboration needs to extend beyond the institutions of higher learning to include the private sector, NGOs and other stakeholders.

Access to networked technologies also has the potential to reform teaching and learning in African universities. First, networked technologies are important in developing 21st century skills in learners. The information reasoning, teamwork, cultural understanding, and information literacy skills which are quickly becoming standard skills for participating in a global knowledge economy can be developed through effective use of ICTs. For instance teachers at schools with computer labs are 3.7 times more likely than other teachers to assign independent research and 45 times more likely to assign collaborative work.[2] Moreover, it is shown that the availability of computers and the Internet significantly increases the likelihood that teachers will assign work involving active learning.[3]

2. The Uganda VSAT Rural Connectivity Project Evaluation Report, July 2005.

3. Ibid.

In a world where most of the ideas, research and knowledge exist outside of the borders of a university campus, institutions of higher learning need to be connected and communicating with this outside world. Indeed, networked universities can play an increasingly critical role as engines for growth and development through the generation of ideas and innovations critical for economic development. Universities however need to have the basic infrastructure to facilitate this collaboration. In Africa, universities face a serious handicap with their poor quality and high cost connectivity.

References

Gaible, E. and S. Nadel (2005), The Uganda VSAT Rural Connectivity Project Evaluation.

Steiner, R., N. Tirivayi, M. Jensen and K. Gakio (2004), African Tertiary Institution Connectivity Survey.

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