Bandwidth bottlenecks at the University of Botswana

Complications for library, campus, and national development

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Abstract

Purpose – To examine the technical reasons for excessively slow internet speeds at the University of Botswana, to discover the present state of development efforts addressing such examples of the qualitative digital divide, and to recommend remedies.

Design/methodology/approach – Surveys of students, the authors' professional experiences, and reports from corporate, public, and intergovernmental organizations provided insights into the effects – and causes – of internet slowdown.

Findings – Bandwidth bottlenecks were identified in successive stages of intercontinental internet traffic. Causes included network design and capacity, telecommunications regulations, and competing budgetary demands within Botswana.

Research limitations/implications – Much of the literature on the digital divide has stressed plentiful hardware and internet connections in affluent societies versus their scarcity in developing societies. This study illustrates that hardware and connections are necessary but not sufficient for adequate online performance. Technological advance and development can each stimulate the other, and that two-way interconnection necessitates more than a simple call for more spending to increase developing countries' bandwidth. The paper presents recommendations in addition to higher funding.

Originality/value – Student and other micro-level data serve as measures for the local performance of a global utility, the internet. Tracking message transmission uncovers bottlenecks along the path of the intercontinental internet, specifically as it reaches Africa. These "street-level" approaches can assist the international aid community, the telecommunications industry, and the public sector in Botswana and elsewhere in removing obstacles to the internet as a potentially important tool for national- and human-development.

Keywords Internet, Botswana, Developing countries

Paper type Research paper

Introduction

The people of Botswana proudly refer to their national university, the University of Botswana, as "U.B.". As the flagship higher educational institution in its land, UB is an up-and-coming institution of higher learning in a country ranked by the World Bank as "upper middle income" along with such nations as Brazil, the Czech Republic, Hungary, and Mexico (World Bank, 2003). Botswana's gross national income per capita is at the lower end of that cohort; thus it is neither impoverished nor nearly as affluent as the developed nations ranked by the World Bank as "high income". In fact, Botswana's per-capita gross national income is about a tenth of the USA's (World Bank, 2003). Nevertheless, Botswana has emerged from the "lesser developed countries" group, and with a rather low population of 1.7 million at its 2001 census (Economist Intelligence Unit, 2004) scattered in a land about the size of France, Botswana is known for substantial economic resources stemming from diamonds, cattle, and tourism.

The penetration of information and communication technology (ICT) is high at UB, with 160 internet-enabled computers in the library and 869 more in labs on the campus. Considering the above, Botswana's university seems unlikely to be suffering from the kind of disadvantage widely known as the "digital divide". Yet, in the experiences of both joint authors and their respective students, there are unpleasant surprises at UB when it comes to internet connectivity. (One joint author is a senior lecturer at UB, and the other taught there as a visiting Fulbright lecturer and scholar during the academic year of 2002-2003.)

The essential services of the university and its library are clearly impacted. The UB library offers some electronic (and print) resources that are the earmarks of well-equipped academic libraries anywhere (for example, a leading-vendor's OPAC, aggregated full-text databases, and document delivery). Nevertheless, work in nearly every university setting, whether public workstations in library, electronic classroom, lab or dedicated workstations in faculty or other offices, is crippled by response times that are slow to the point of dysfunctional and often involve waits of many minutes for pages to load. Here are some symptoms.

(1) The system tray of a personal computer in a typical office at UB displayed until recently a constant access speed of 10 Mbps. By contrast, the same reading on an office computer at Union College, NY, USA, reads a constant access speed of 100 Mbps, a difference of ten times greater speed than at UB. (The rate indicated in the system tray measures that interval bounded by the personal computer and the final router or switching point to which it is connected.) Finally, in 2004 a standard 100 Mbps has been reached in the desktop hardware at UB.

(2) CNET Bandwidth Meter is a free online service that measures speed of access of an internet user's computer in terms of bandwidth (CNET Services, Inc.). Checking the bandwidth meter from the same two personal computers in Botswana and in the USA described above, one year apart, yielded the following. The computer at UB registered bandwidth access of 29 kbps in February 2003, while the computer at Union College registered 3225.3 kbps in March 2004. Even allowing for some amelioration over the intervening year, that approaches a difference in the neighborhood of 100 times less bandwidth and speed for the Botswana computer, as measured between personal computer and the web site of CNET, a corporation located physically in San Francisco, California, USA.

With two such measures as well as our students' (and our own) frustrations as internet users, the joint authors have tested students' perceptions on the subject in various ways. For one, the Library and Information Studies undergraduates of LIS 212, Information Resources in Business, and the graduate students of LIS 624, General Management in Information Services, were surveyed in January 2003, as to their use of the internet at UB, with respect to both queuing for physical access to a computer and waiting for those computers to respond.

For both types of delays, respondents were asked to indicate the purpose for which they were seeking to use the computers of the UB library or its labs. The results follow: (Note: Thirty six students completed the survey, for an overall response rate of 73 percent. Respondents could choose more than one purpose, so the total in Table I exceeds 100 percent.)

The purposes range from off-line applications like word-processing, to local-campus-network applications such as searching the library catalog or local e-mails, to full internet use. (Queuing for computers is not the issue here, so that data are not reported.) Response time is in part a function of the purpose to which the computer is put. How does the computer actually perform for these UB students? The data appear below in two forms, tabular and graphic. Table II shows the patterns of delay aggregated for all purposes. Simply, the longer the time interval, the more students experienced it.

Figure 1 isolates the internet-related purposes and the delays associated with using the internet, such as e-mailing, using library-source databases, searching the web for academic purposes, and utilizing it for recreational purposes. Generally, the farther to the right in Figure 1 (i.e. length of delay increasing), the more students responded.

Substantial delay is experienced when UB students seek direct connection to the internet: six out of seven database inquiries (86 percent) required more than a minute of waiting after clicking the mouse; 17 out of 27 academic-related searches of the web (63 percent) required more than two minutes of waiting; four out of seven recreational web uses (57 percent) required more than two minutes.

Purpose of computer use (ranked highest to lowest)	Number of students responding	Percentage of total (36 students)
Searching the web for academic purposes	27	75
Word-processing	23	64
Library catalog checking	18	50
E-mailing	7	19
Relaxing (e.g. playing games, "surfing")	7	19
Using databases	7	19

Note: Total exceeds 100 percent because respondents could choose more than one purpose

Delays in computer response (minutes)	Number of students responding	Percentage of total (36 students)
0	0	0
<1	8	22
1-2	8	22
2-5	9	25
>5	11	31

Table III focuses on the longest delays, i.e. the categories of more than two minutes and more than five minutes. Quite a number of students were kept waiting for more than two minutes per mouse click; many were even kept waiting for more than five minutes. That would surely try the patience of anyone expecting that the internet would perform as often experienced in the developed countries.

Corroborating evidence

This small sample is no aberration; it confirms data previously gathered from a large sample of UB students in 1999-2000 (Ojedokun, 2001). With an exceptionally high response rate (98.6 percent of 1,500 students polled), a very low rate of full internet use was reported then: non-users numbered 23 percent, and those using the internet less than three hours per week total were 60 percent of the sample. The most frequent purpose of internet use was then e-mail, and Ojedokun concludes, "The majority of the respondents were not using the WWW for academic matters" (Ojedokun, 2001). Respondents cited four reasons for their low use, and in decreasing frequency of reporting, they were:

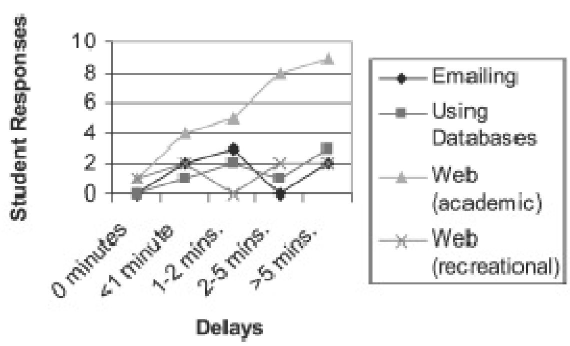
(1) insufficient numbers of computers available;

(2) inadequate training;

(3) slow response time (emphasis supplied); and

(4) restrictions in time allocated to each user.

The survey of UB students in 2003 indicates that since the Ojedokun survey there has been a sharp increase in the frequency and the purposes to which campus computers are put to use. Training has greatly improved, and in particular, the mandatory General Education Curriculum for undergraduates in their first three years can be credited for widely upgrading skills in several areas of student need like computing, writing, study, and library use.



Long delays by purpose	2-5 minutes	Percent	>5 minutes	Percent
E-mailing	2 students out of 7	29	2 students out of 7	29
Using databases	4 students out of 7	57	3 students out of 7	43
Searching the web (academic)	17 students out of 27	63	9 students out of 27	33
Searching the web (recreational)	4 students out of 7	57	2 students out of 7	29

However, the 2003 survey data show that slow response time has not substantially improved. In fact, if numbers (1) and (2) on the above list of reasons found by Ojedokun have indeed been ameliorated – i.e. increases in computers available and in training – the result is more students using more computers, thus drawing further on computing resources and quite likely degrading response times further. The Head of the Department of LIS observed in 2003 that students in her department had difficulties in their learning owing to, among other things, poor connectivity through the university's network (Moahi, 2003).

Even more recently, in a study to determine the status and level of information literacy within the academic programs of the LIS department at UB, students continue to cite poor connectivity and quality of internet access. Respondents observe that with extensive information now available through the world wide web, internet connectivity and access at UB needs to be more efficient and reliable if they are to undertake their assignments effectively (Mutula *et al.*, 2004).

What lies behind the problem? Little work has gone into unpacking social and other implications of the global digital divide; however in Egypt, for example, purely technical solutions have been shown as simplistic (Warschauer, 2003). Technology may be lacking, yet thrusting more of it into an imperfectly understood gap may achieve little. At UB, "technology" in the form of equipment, network connections, and technical expertise is already much in evidence, UB being a well-financed and staffed university in a nation ranked in the upper middle of all national economies. Why would there be a consistent and severe performance problem with the internet in such a setting? How can the problem be best addressed? Of what meaning is it to development?

The crux of the problem: bandwidth

It is the contention of this paper, first, that internet response delays on the UB campus are traceable to shortages of incoming bandwidth, the measure of the amount of information (usually bits, megabytes, or even gigabytes) that can be carried in one second over a given telecommunications circuit[1]. Bandwidth for incoming internet traffic is widely recognized as "the metric for the quality digital divide", because its scarcity degrades performance (International Telecommunication Union, 2002).

Second, the bandwidth "squeeze" itself will be traced. That is, the internet arrives at the individual workstation at UB via a journey of many stages through routers and exchange points, each successively farther removed from the user: the network of the UB, then its internet service provider (ISP), then the country's gateway the Botswana Telecommunications Corporation (BTC), then the internet's entry from overseas i.e. Europe and North America – into the African portion of the network. Bandwidth bottlenecks could occur at any one or more of those stages in the internet's transmission. The following four sections parse that lengthy pathway and examine how each may contribute to delays.

From UB's network to the individual user

By the academic year 2002-2003, when the above student data in Tables I-III and Figure 1 were collected, UB's network had been upgraded from copper wiring to fiber-optic cabling, although the delivery standard is integrated services digital network (ISDN) rather than a more fully broadband-capable, high-speed connection like a digital subscriber line (DSL). Student and lecturer experience certainly reflects the results of ISDN-level delivery, only partway to broadband service levels. It is known, for example, that a 1.8 Mb file downloads in 25 seconds via DSL connection, 3.5 minutes via ISDN, and 7.5 minutes over a 56 kps modem (International Telecommunication Union, 2002). Though 1.8 Mb exceeds the size of many web-pages, relative speeds hold true, and the student and lecturer experience at UB is consistent with that data.

Not only does the UB infrastructure stop short of "state-of-the-art" but the load upon it has grown enormously. Expansion of higher education is a high national priority, and by 2003-2004 enrollments have reached 13,000 students at UB, where as recently as 1999-2000 there had been only 8,000 students. Growing enrollments are draining computer (and other) resources on campus at an ever-heavier pace. Although UB has a forward-looking information technology strategy, the provision of ICT must compete for financial resources across this growing university in order to improve the bandwidth supply. Yet, in the most recent national budget, UB was not allocated any funds for capital improvements (Gaoloathe, 2004), a probable consequence of ever increasing demands upon public monies for fighting HIV/AIDS in Botswana. The IT department at UB pleads that it could buy more access to bandwidth, where it allocated sufficient funds to do so.

From Botswana to the UB network

Questions also point to the internet's transmission before reaching the campus. There are 14 ISPs in the country of Botswana, positioning Botswana as one of the leaders in Africa in number of ISPs and hosts (Afullo, 2000). Bandwidth is allocated to ISPs through BTC, the para-statal enterprise that also handles landline telephone systems (Mutula, 2002). Botswana boasts a national network of digital microwave and fiber-optic cabling with digital equipment at main exchanges (PriceWaterHouseCoopers, 2002). While yesterday's analog technology is not the problem, full upgrading from copper to fiber-optic lines has not yet been accomplished in the country at large, with certain exceptions. Those are the fiber-optic circuits at the UB campus and others for dedicated use by such agencies as Botswana Power Corporation, Botswana Railways, Botswana TV, and the police (Mutula, 2004). Botswana lags somewhat behind the USA, Western Europe, Japan, and New Zealand, where optical cabling is now the norm for trunk lines (International Telecommunication Union, 2002). The country ranks in 44th place on a global networked readiness index of Harvard's Center for International Development (Mutula, 2004).

What holds BTC back? With intent to be progressive, it has introduced "local-loop" wireless technology to expedite new landline telephone connections (although service has been severely compromised whenever the line-of-sight between home receiver and BTC's send/receive dish has been blocked). However, some telecommunications utilities in Africa are known not to favor upgrading to fiber-based broadband DSL, reluctant to reinvest current revenues in order to raise the necessary capital investment for re-cabling, despite hopes for potential future gains from faster service (International Telecommunication Union, 2002). Clearly, BTC is a firm that has been through a difficult financial period, as publicly reported in the Botswana press, and its outlook, in Botswana President Festus Mogae's recent State of the Nation Address, is "bleak" with projected losses in the millions of pula, the equivalent of about US$6 million for

2001/2002 (Mogae, 2002). BTC has recorded losses for three years running in fact, despite its monopolistic control over bandwidth (Mutula, 2002).

Limits to competition, in fact, may be at the crux of the problem for the national network, in that legislation in 1996 took BTC only part way toward liberalization. For instance, the practice of peering in which hosts exchange traffic in order to streamline and speed message flow[1] was not among the changes permitted. Obstacles were left in place that still prevent application of the Voice over Internet Protocol (VoIP) and access by the public to the national government's own network. Worse, BTC has been disciplined by the "watchdog" Botswana Telecommunications Authority for acting in conflict of interest in favoring its own ISP, Botsnet, in bandwidth allocation (Mutula, 2002).

It is unclear whether smoother coordination or unbridled competition would better suit the national internet infrastructure, but the situation in Botswana leaves room for improvement in both. President Mogae expresses a national aim "to achieve availability and delivery of affordable quality information and communications technology services to all" in the country… by 2016 (Mogae, 2002). "Vision 2016", Botswana's blueprint for national development named for the year of its prospective 50th anniversary, repeats the call (Presidential Task Group, 1997). However, without a specific national policy on ICT to implement, the country as a whole, with or without a liberalized BTC, is left in a weak and uncoordinated position. Moreover, the year 2016 is a long wait for a country already enjoying moderate economic growth.

The internet into Botswana

Problems of within country distribution of the internet – stemming from campus realities or telecommunications regulation – do not rule out other loci for a bandwidth bottleneck. The internet's arrival into Botswana needs to be examined.

Starkly, Botswana's entire incoming bandwidth is 14 Mbps (International Telecommunication Union, 2002). By comparison, 14 Mbps is substantially less than that of a medium-sized college in the USA, namely Union College, which is supplied with 20 Mbps of bandwidth (Information Technology Services, Union College, 2004). Clearly, the governmental, educational, commercial, and private users of Botswana are under-supplied relative to a single American college campus with student, faculty, and administrative users totaling less than 3,000 people. Whether comparing that number to UB's enrollment of 13,000, plus staff, or to the entire nation of Botswana at 1.7 million, there is a striking contrast and unbalance in bandwidth supply.

In perspective, however, few African countries are better internet-bandwidth-supplied than Botswana: in 2002 only ten African nations had more than 5 Mbps, and the 23 other internet-connected countries had less (Ngini *et al.*, 2002). That places Botswana, though not well-supplied in comparison with developed countries, in the upper-range of bandwidth among African countries. Botswana is only exceeded by its larger and generally more economically developed neighbor South Africa, reported to have about 80 times more bandwidth for data communications than Botswana (Afullo, 2000).

Botswana does not lack for satellite-based delivery of data. A known problem among cash-short developing countries arises from short-sightedly selling off their allocated slots in the geostationary satellite system. Happily, Botswana has not made that move and today uses satellite delivery for some of its internet and international telephone circuits, as do the other members of the Southern African Development Community (SADC) (Mashungwa, 2002).

This mixed news about Botswana's bandwidth, however, is worsened by the patterns of regional African internet traffic. Just as peered routing techniques are underutilized (and in fact forbidden) within Botswana, so Botswana's connectivity to sites in its geographic neighborhood is not optimized. Such regional peering, were it effected, would spare countries excessive reliance on longer-distance, higher-cost connections to Europe and North America (Jensen, 2002).

Indeed, Africa largely lacks regional peering and inter-regional routing. Predominantly, each country connects separately to the overseas circuits. In fact, two-thirds of African bandwidth carries US-linked traffic (Ngini *et al.*, 2002). Ensuing tariffs require countries to incur high costs with payment in US or Canadian dollars, leading to cash flow in directions wholly counter to development (Cullen, 2001). Cash diverted to unnecessarily high transmission costs cannot be used for the hardware upgrades that improve bandwidth. Anecdotal evidence of UB students' e-mail practices confirms that those students, like many other African e-mail users, opt for free Hotmail, Excite, or Yahoo accounts hosted in the USA and requiring scarce, costly, overseas bandwidth.

Africa may have five million internet users, but many are confined to e-mail use only and lack the connectivity to browse the web effectively – for them full internet access "is still a long way off"(International Telecommunication Union, 2002). Botswana is arguably farther along, by comparison with other parts of Africa, but the target year of 2016 in the Botswana government's national telecommunications strategy is a relatively distant date to achieve parity with the developed world (which by then will have moved still further on). The 400,000 residents of Luxembourg enjoy greater bandwidth than 760 million African people (1.3 Gbps for tiny Luxembourg versus less than 1 Gbps for all of Africa) (International Telecommunication Union, 2002). That makes the situation at UB, one of Africa's finest universities, fit coherently into the big, but not-too-rosy picture.

From the intercontinental circuits into Africa

Data-transmission bottlenecks that could occur prior even to African arrival depend upon the route that the internet takes. Two modes are in operation, varying in connection capacity and speed. Satellite and undersea cable (the latter relayed through South Africa, as Botswana is landlocked) are both used by Botswana.

The undersea fiber-optic cable mode has been until recently facing limits in carrying capacity. "South Atlantic Telecommunications cable number 2" (SAT-2) had been carrying 1 Gbps of bandwidth into Africa under the sea from Europe, although demand exceeded that capacity, bringing slowdowns under conditions of peak loading (De Wet, 2002). Two competing submarine cable projects are bringing needed upgrades. One was immersed in the sea and brought online in mid-2002, a project entitled "South Atlantic Telecommunications cable number 3"/"West African Submarine Cable"/"South Africa Far East" (SAT-3/WASC/SAFE) bringing Africa 30 times the previous cable bandwidth (30 Gbps) initially, (Telkom South Africa, Ltd., 2004) with more projected, and a hoped "technological breakthrough of great significance to Africa" (Republic of South Africa, 2004).

Originating in Portugal, heading south along the west coast of Africa, rounding the Cape of Good Hope, heading eastward out to Réunion and Mauritius, and finally arriving in India and ending at Malaysia, SAT-3/WASC/SAFE is an engineering venture jointly financed by 36 nations, projected to be useful for 25 years. The new submarine cable currently offers nine African landing points, and because the stakeholders are substantially African, there is more gained than bandwidth alone. Internet traffic may flow more readily throughout Africa without "premature" routing into foreign systems, as noted above, with an unnecessary drain on African ISP revenues (Republic of South Africa, 2004). It is hoped that the resulting lower usage tariffs will in turn free up hard currency for investment in broadband.

Competing with SAT-3/WASC/SAFE is another submarine fiber-optic project called Africa ONE, intended to encircle Africa and bring 2.5 Gbps of bandwidth capacity to each coastal country and then interconnect to landlocked countries (Afullo, 2000). Reports on Africa ONE, initiated by AT&T and with private backing only, indicate that it is lagging behind schedule owing to funding shortfalls (Balancing Act, 2001). Africa ONE's web site (www.africaone.com), although "live" in February 2004, has ceased to be available as of March 2004. Africa ONE may still come to play a positive role in supplying better response time for African internet users like those at UB. Nevertheless, it is an open question when, or whether, Africa ONE will eventually become a reality.

Landlocked Botswana receives benefit from such submarine cable projects indirectly, via neighboring South Africa. That country reports a recent upgrade in its microwave and optical-fiber transmission system to Botswana, using synchronous digital hierarchy technology (Republic of South Africa, 2004).

Whether satellite or submarine-cable or both become the long-range choice to carry the internet into Botswana is as yet undetermined. Because the submarine cables have recently been full-to-capacity, the transmission into Africa, thence Botswana, has contributed at least in part to the bottleneck. South Africa's telecommunications corporation Telekom SA, Ltd., considers that undersea cables "generally offer better efficiency, reliability, and security than satellites" (Republic of South Africa, 2004).

Satellite transmission can deliver regional traffic. Through the Very Small Aperture Terminal (VSAT) approach, satellites can feed individual houses, cybercafes, schools, etc. as "miniature earth stations" and bypass the landline problem, especially in rural applications (International Telecommunication Union, 2002) However, sending data by satellite directly into the predominately urban telecommunications network of a land-locked Botswana would not alone ameliorate the bandwidth bottleneck if it is down-linked into lines that are chiefly copper, not high-speed fiber, or are simply scarce or otherwise unfriendly to broadband transmission. The same can be said for submarine-to-land cables. These "macro" systems by which the internet is carried to the African continent have played a partial role in the bandwidth bottleneck.

Bandwidth bottlenecks and the "new" digital divide

There are reasons for slow internet performance in evidence at each step in the path before the internet reaches the end user at UB. Each step separately could be a contributor to delay. Acting in concert, two or more multiply the effect. To summarize:

- within UB itself there is a delivery standard no higher than ISDN, and enrollment growth outpaces system capacity;

- beyond the campus, Botswana has yet not achieved universal fiber-optic cabling;
- the national telecommunications agency BTC has suffered recent consecutive years of financial loss and maintains vestiges of monopolistic practices that, among other things, prohibit peering among the ISPs in Botswana;
- the provision of bandwidth to the whole of Botswana is relatively scant, coming in, in part at least, via a recently over-taxed submarine cable relayed through South Africa; and
- regional internet connection and peering within Africa remain principally in the future for the continent.

The UB end-user's experience with the internet is symptomatic of what is now being called the "new" or the "quality" digital divide (International Telecommunication Union, 2002). That is, the gap is not attributable to the lack of equipment or connections. Up-to-date hardware is in place at UB, and yet users' high expectations are steadily lowered because downloading the large-sized, graphics-heavy pages typical of today's world wide web without undue waiting times is not widely available in Botswana. Simple access to the internet means little without a sufficiency of bandwidth accompanying it. In its present form, the character of the digital divide is changing from "basic to advanced communications and from quantity to quality" (International Telecommunication Union, 2002).

Wireless possibilities

How might mobile technology assist UB in achieving better connectivity? Many developing countries have low "teledensities" (i.e. number of telephones per 100 people), a problem ripe for solution by cellular telephone. Botswana's telephone ownership, though indeed considerably lower than in the US or Europe, is ten times higher than the African mean (International Telecommunication Union, 2002) and is readily spreading for the well-known reasons of lower cost than landlines and an income-independent pricing structure via prepaid phone cards. The expense and waiting time for landline connection will continue to mitigate against the conventional telephone's role with individual African users of the internet.

Will wireless internet access alleviate bandwidth scarcity at UB? As previously described, the UB campus is already supplied with a fiber-optic network, so mobile connectivity is not the answer. Full internet functionality, however, is needed at an institution of higher learning, just as it would be at a large corporation or a substantial government facility. Mobile-phone data interfaces for academic users like UB (and others) do not fit well with the typical academic requirements of lengthy sessions combining searching with reading, researching, and writing. Small-screen internet on a pay-as-you-go basis is not well suited to much academic, professional, and governmental research activity.

For the citizenry at large, mobile-phone access could especially help remote, rural internet users. A newly reported development (WiMAX or "Wireless Maximized") is promising (Van Grinsven, 2004). With WiMAX, fixed-line telecommunications systems utilize mobile technology to carry voice and data out beyond the farthest extent of land lines and thereby deliver a wireless "final mile" that can reach up to 30 miles in any direction from any land-line terminus. This potentially could extend internet access to most of Botswana's population and save on capital investment in new landlines.

The African Internet and Telecom Summit held in 2000 in the Gambia resolved that mobile networks become "the predominant carriers of the future internet traffic" (Mwakatobe, 2000). Yet, there are technical, cost, and functionality considerations in the path ahead for mobile internet. Technically, Botswana will be better positioned for wide mobile-phone internet access if its system develops along the lines of the Japanese model. Japan's NTT DoCoMo instituted "I-mode" rendering ready access to the internet via mobile phones as early as 1999 (Faiola, 2004). Cell phone standards in the US, for instance, make it more difficult for American than for Japanese phones to utilize the internet.

Development implications

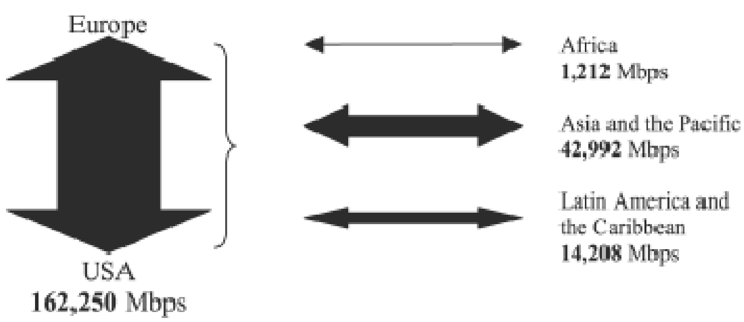
Importantly, number of projects are bringing ICT-related investment into Africa. The United Nations Information and Communication Technologies Task Force maintains on its web site a database of ICT-assistance revealing considerable investment originating, for example, in Canada, the US, France, Sweden, Japan and Australia, as well as IGOs like the UN and EU (United Nations, 2004a). Thumbnail sketches of some major efforts include:

- The United Nations' own Global Digital Opportunity Initiative, launched in 2002 by the UN's Development Programme jointly with the Markle Foundation to "bring *pro-bono* expertise and resources to developing countries" and in doing so link the efforts of corporations and NGOs (United Nations, 2004b).
- Actual capacity building, i.e. installation of physical equipment, the focus of the Internet Initiative for Africa, established as above by the UN's Development Programme, with the remit to upgrade internet connectivity infrastructure and improve bandwidth on the African scene (United Nations, 2004c).
- Optimizing traffic flow through peered routing, the concern of the African Information Society Initiative. Also UN sponsored, under its Economic Commission for Africa, its objective is to foster robust regional sharing of bandwidth, with the objective of "facilitating greater interconnectivity between countries… to help resolve local imbalances and inefficiencies through the development of common networks and regional backbones…" (African Information Society Initiative, 2003).
- National-level initiatives include the USs' Leland Initiative, a noted effort by the US Agency for International Development (USAID) to extend "full internet connectivity" to 21 African countries including Botswana (U.S. Agency for International Development, 2001). Although the five-year, US$15 million mandate of Leland is finished, the Leland Initiative's web site continues to exist at this writing; perhaps a new infusion of funding is planned.
- Together the G8 countries instituted their Digital Opportunity Task Force (DOTForce) culminating with a report in 2002 when it disbanded and converted its committees and resources to the above-mentioned United Nations Information and Communication Technologies Task Force. DOTForce was clear about bandwidth imbalances around the globe in its final report, *Report Card: Digital Opportunities for All*, from which the striking differences shown in Figure 2 are derived (Digital Opportunities Task Force, 2002).

As these IGOs and countries with the greatest material resources commit aid funds to upgrade Africa's comparatively scant bandwidth, would their "top-down" approach alone produce concomitant improvements in "final mile" performance? The situation at UB indicates that more is needed. In Botswana's case, internal restructuring of the telecommunications agency BTC in its relationship with the extant ISPs is an important change needed, to complement funding aid. More profoundly, competing socio-economic priorities – how much funding to allocate to educational expenditure while aggressively addressing HIV/AIDS (in Botswana's case) – are development issues that remove ICT-targeted efforts from isolation.

Development and technology are intertwined, or "co-constitutive" (Warschauer, 2003). On the one hand, effective internet access spurs development. Botswana's "Vision 2016" expresses hopes that an information society will enjoy increasing productivity, lowered costs, higher profits, a better quality of life, and most of all job creation (Presidential Task Group, 1997). To be sure, capital-intensive heavy industry may be slow to spread throughout the developing world. However, the internet can offer marketing, information, and employment to all on a level playing field globally.

On the other hand, internet access is farther reaching where development has already occurred. Internet-connected populations vary directly with the GDP-per-capita of their country of residence, as shown by Table IV, in which the countries are arranged in descending order of GDP-per-capita (Cullen, 2001).



Source: Digital Opportunities Task Force (2002)

Countries	Percentage of population with internet connection
USA	55.83
UK	33.58
Israel	17.12
South Africa	4.19
Jordan	1.92
Botswana	1.3
Egypt	0.65
Burundi	0.03

Source: Cullen (2001)

The example of HIV/AIDS exemplifies the co-constitutive interaction of development and technology. The internet as information carrier, among other roles, is a valuable asset in the campaign against the pandemic. Yet, owing to the substantial diversion of Botswana's national wealth for treatment and prevention of HIV/AIDS, the disease in turn acts as an internet-retardant, where fewer funds than otherwise remain available for upgrades. Students of development worry about "the capacity of developing nations to absorb ICTs beyond their level of economic development" (International Telecommunication Union, 2002). Both leading and lagging development, the internet is a technology intertwined with development and social concerns.

Broadband in the developed world

What is now becoming the norm in the developed world would be a real upgrade for Botswana: spreading broadband access. At the same time, there is no standing still for ICT in developed countries. They have their own momentum with regard to internet access: onward and upward. For example, there is the "100 by 100" Consortium in the USA, supported by a US government grant with the mission of improving connectivity to at least 100 million homes in the US to a level of "everyday speeds of 100 megabytes per second" (Gomes, 2003).

Demand for ever higher connectivity levels in the developed world feeds upon itself. The irony of continuously rising expectations is exemplified in a comparison between internet-user satisfaction in Nigeria and that in the UK (Ngini *et al.*, 2002). Reactions were surveyed at a time when Nigerians had access only to a dial-up system offering a slow 64-kbps access speed. Despite their outmoded connectivity, 70 percent of Nigerian respondents expressed satisfaction, while only 55 percent of British users surveyed reported being satisfied with their faster connectivity.

Good access evidently sharpens the appetite for better, and the developing world, even at the national university of a development-leading country like Botswana, lags behind the levels with which the developed countries are already dissatisfied and are attempting to exceed.

Recommendations

Arguably, at the level of simple access, the global digital divide may be narrowing. Through mobile technology, satellite downlinks, and cybercafés or kiosks, ICTs are reaching further afield. Undeniably, Africa is experiencing a jump in the use of the internet, and portions of the continent are enjoying telecommunications recently unheard of. Botswana is marching forward in this dimension with, for example, a current 31 percent teledensity (i.e. per 100 people) for mobile phones (Maitlamo, 2004).

The qualitative digital divide may prove stubbornly intractable for a period, however, and some worry that as the internet advances, the uneven distribution of those advances will deepen, with the gap between "the developed and developing economies of the world, notably the African and Middle-Eastern countries" at its deepest (Ngini *et al.*, 2002).

Other aspects of ICTs may be spreading faster than broadband access to the internet. Global bandwidth differentials, like basic access, vary directly with wealth indicators like GNP-per-capita. For instance, the 15 nations heading the list of bandwidth are all to be found in North America, Europe, and parts of Asia, with South Korea leading the world in broadband (International Telecommunication Union, 2002).

Bringing internet access into the remote rural village in a lesser-developed country is a challenge different than optimizing it at UB, in its library, labs, and offices, or on the desktops of government or business officials in a capital city such as Botswana's Gaborone, where the internet has arrived, but with incompletely achieved performance. Internet-users' experiences at Botswana's national university UB prove that the necessary and sufficient condition for internet operations goes beyond acquiring access alone. Nearly, interminable and unproductive delays deprive end-users of effective network use. Until broadband technology is disseminated and response time is lowered to something resembling the developed world's experience, "the revolutionary potential of the internet has still to be fully tapped" (Roach, 2003).

While it has been said, "Money is the single-most important factor in bringing the internet to the African continent" (Kowalczykowski, 2002), it is facile to call for higher funding alone to smooth the way for fuller, speedier internet access in all the circumstances found throughout the developing world. We learn from the relentlessly slow performance of the internet at UB that it is not "a gap (that) can be filled by the provision of equipment" but that there are, at play, "more complex long-term processes" (Warschauer, 2003) which pose more challenges to development than straightforward funding increases can meet.

Therefore, while increased international aid (whether it comes through corporate, governmental, or combined sources) is a *sine qua non* recommendation, nevertheless certain other accompanying changes are needed:

- reworking of the internet's configuration itself to encourage more regional and within country traffic;
- influence upon the national telecoms agency to adjust policies that block efficiencies;
- the will, at the national government level, to supply growing educational institutions with support sufficient to increased enrollment; and
- a policy of educational and cultural support by the national government without diminishing its response to national health needs.

We learn from this example of shortfalls in high-quality internet performance that an over-arching principle of technology and development should be steady, unwavering focus on the experiences of actual users in everyday situations. How do they testify to internet performance? Students and lecturers at the UB reasonably expect their workstations to serve up web-pages better and faster than they, in actuality, do. Dashed expectations on their part represent a development failure.

The work here shows that the problem is indeed traceable. At the same time, the problem does not stem from a simple or singular causative explanation. More development funding is one, but not the only, answer, and continued monitoring of its most localized effects is essential.

Note

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