

Bandwidth management in universities in Zimbabwe: Towards a responsible user base through effective policy implementation

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ABSTRACT

This research was undertaken to investigate the issue of how to maximise or make efficient use of bandwidth. In particular, the research sought to find out about what universities in Zimbabwe are doing to manage their bandwidth. It was, therefore, appropriate to survey a sample of five universities and to catalogue their experiences. Results show that most universities in our sample did not have an official Acceptance Use Policy (AUP) to assist with bandwidth management. Successful provision of managed network bandwidth within a university is likely to involve the application of many tools encompassing a number of different techniques. These products are often expensive and are rarely available for loan. Fortunately, a cost-effective solution exists for all universities that can be deployed regardless of the campus' existing network configuration or installed devices. The authors recommend that using Quality of Service (QoS) and Bandwidth management will enable network administrators to control network traffic flow so that appropriate users and applications get priority during the allocation of network resources. Also, universities must contain in their IT policies a meaningful AUP which will help universities to develop and refine usage and access as well as plan for network resource allocation.

Keywords: *Bandwidth Management, Acceptable Use Policy, Policy implementation*

BACKGROUND TO THE PROBLEM

Universities in Zimbabwe are under pressure to provide their students and lecturers with reliable Internet access. As Internet connectivity is increasingly becoming a strategic resource for university education, a robust campus network with good connectivity to the Internet is no longer a luxury to a university, in actual fact, it is now a basic necessity. Internet connectivity is critical for any university to participate effectively in the global knowledge society. The use of the Internet can enhance the efficiency and capacity of universities in Zimbabwe to provide quality education and the conduct of high calibre research work. Internet connectivity provides a gateway to vast amounts of information from the information highway and thus provides support and enhances research efforts by both students and lecturers. Many universities in Zimbabwe have set aside a significant fraction of their budgets towards increasing their bandwidth and upgrading their networks.(Chitanana, Makaza and Madzima 2008). Despite considerable investment in bandwidth, many of these universities are still finding themselves not having reliable, usable Internet access for their students and staff.

The demand for bandwidth within universities is constantly rising and the overall bandwidth usage continues its upward trend. This demand is caused by, among other things, increased student enrolment, the increased use of electronic resources for teaching and learning, and the spread of desktop applications that can use practically any amount of bandwidth given to them. A definite trend is continuing towards multimedia websites, which contain bandwidth-hungry images, video, animations, and interactive content. Students use the Internet in many different ways, some of which are inappropriate or do not make the best use of the available bandwidth. Not all of these activities could be described as having much academic worth and indeed some may be viewed as undesirable by any standards. Bandwidth is often consumed by low priority, bandwidth hungry

uses for non-educational purposes. However, restricting this altogether may not be the solution since this leads to frustration on the part of the user.

As the popularity and usage of heavy bandwidth consuming applications grows and the number of network users multiplies, the need for a concerted and co-ordinated effort to monitor bandwidth utilisation and implementation of effective bandwidth management strategies becomes increasingly important to ensure excellent service provision. The absence of a bandwidth-management strategy will leave a university's network at risk of being hopelessly bogged down, to the point where users are denied access to this valuable resource. Even in situations where high amounts of bandwidth are available, controls, monitoring and optimization are necessary because users will always find ways to fill the available amount of bandwidth.

Since bandwidth is a strategic resource, the efficient usage and management of such a resource should always be a priority. Without bandwidth management, mission critical applications would be starved of bandwidth, disrupting services that impact the operational activities of a university. As such, this study sought to illuminate the bandwidth management strategies that were being employed by universities in Zimbabwe. The research concentrated on policy based bandwidth management strategies.

THE PROBLEM

The demand for bandwidth within Universities in Zimbabwe is on a constant rise. The available bandwidth is generally not enough to meet demands and to support optimal usage. If universities are to participate in high-end quality research, they must invest in substantially more bandwidth. However, the TERENA compendium (2007) notes that the current level of planned bandwidth increase reported for the next five years is not enough for universities in Africa. Universities are faced with a major challenge in their use of the Internet. The major challenges experienced by universities are:

- Students' overuse of undesired applications.
- Copyright violations due to peer-to-peer (P2P) file sharing.
- Poor application performance and Quality of Experience (QoE) during congestion.

Increased student enrolments and shifting patterns of Internet access and usage continue to generate resource and administrative challenges for many universities in developing countries. Apart from the limited bandwidth, the improper use of existing connectivity is a major challenge. Inappropriate use of existing bandwidth, due to absence of bandwidth management strategies promotes bandwidth wastage on unwanted traffic such as viruses, music and movie download by some users (Oyewole, 2009). The largely unrestricted access exposes the university Internet connectivity to bandwidth-hogging applications such as peer-to-peer (P2P) file sharing and media streaming. Audio and video streaming applications embedded in Web sites like YouTube have grown in popularity among students. Although universities may increase their Internet capacity by purchasing additional bandwidth from one or more Internet Service Providers (ISPs), it is very expensive to do so because the price of bandwidth in Zimbabwe is still exorbitantly high. No matter how much more bandwidth is bought, a point will be reached when one can no longer buy more bandwidth and therefore the need to look to bandwidth management is necessary. Furthermore, increasing Internet capacity cannot be done affordably considering the rate at which unmanaged applications consume it.

It is therefore the duty of the Information Technology Services (ITS) department to make sure that the available Internet facility is effectively and optimally used to support the core business of a university, that is, teaching and research. It is now recognised that one of the tasks that University ITS directors need to tackle is the management of bandwidth. Effective management of

bandwidth is widely recognized as being the easiest way in which universities can improve their access to networked information resources. The challenge of this problem is how to make more bandwidth available and how to manage the limited bandwidth in the best and most efficient way. Although there are technical issues relating to bandwidth management, the biggest challenge is to raise awareness of the importance of conserving and using bandwidth responsibly by the users.

RESEARCH QUESTIONS

This research sought to answer the following research questions:

1. What is the current state of Internet connectivity in universities in Zimbabwe?
2. What bandwidth management techniques are employed in universities in Zimbabwe?
3. What challenges do universities face in employing bandwidth management strategies?

SIGNIFICANCE OF THE STUDY

This study was designed to access the bandwidth management strategies employed by universities in Zimbabwe and the challenges faced in the process. The results of the study should help universities to recognise that bandwidth is a valuable institutional resource that needs to be managed, conserved, and shared effectively via innovative management approaches. It is hoped that the results of the study will make university authorities realise that this effort will be greatly facilitated by the formulation and implementation of an institutional bandwidth management strategy. Managing bandwidth improves the performance of Internet connectivity by removing unnecessary traffic, making Internet much more accessible, especially for those with a very slow connection.

WHAT IS BANDWIDTH MANAGEMENT?

Bandwidth management is a generic term that describes the various techniques, technologies, tools and policies employed by an organisation to enable the most efficient use of its bandwidth resources. According to Kassim, et al (2012) bandwidth management is a process of allocating bandwidth resources to critical applications on a network. Bandwidth management aims to improve performance of an Internet connection by removing unnecessary traffic. The goal of managing network capacity is to have the right amount of bandwidth in the right place at the right time for the right set of users and applications (Sharma, Kumar and Thakiu, 2011). By efficient use, we mean both the minimisation of unnecessary bandwidth consumption and the delivery of the best possible levels of service to users. It may be asked what bandwidth size is adequate for a university? The answer is that, no bandwidth size can ever be enough to meet the ever increasing user demands in the absence of an effective bandwidth management strategy. In practice, even a bandwidth size of just 4 mbps, for example, can be a viable connection for an average university in Zimbabwe and a lot is possible with such connectivity. However, it requires simultaneously good content in appropriate formats, good local network management and design, good bandwidth management policy (in particular an Acceptable Use Policy), and user education to understand their responsibilities to use the scarce and expensive resource effectively (Habler & Jackson, 2009).

Bandwidth management involves the creation and enforcement of network policies to ensure fair and satisfactory network performance. It becomes the tool used to ensure enough bandwidth is available to meet the traffic needs of those mission-critical and time-sensitive applications and prevents competition between these applications and lower priority traffic for the limited network

resources. Bandwidth management has the goal to ensure the availability of Internet bandwidth to everyone.

POLICY BASED BANDWIDTH MANAGEMENT

This study explored how universities in Zimbabwe manage their bandwidth with the view to see how universities might take advantage of the cost effective policy based bandwidth management strategies as a major strategy in managing this scarce resource. A network policy is a statement of opinions, intentions, actions and procedures that guide the overall use of the network to meet the organisation's goals and objectives. Policy-based bandwidth management involves the allocation of network-based resources and services in accordance with the mission and management policies of an organisation. It is tempting to think of bandwidth management and optimisation as a technical issue requiring a technical solution. This is not always the case. According to Gakio (2006) bandwidth management is being viewed as a set a set of tools that need to be installed, rather than a fundamental change in attitude that needs to be imparted to all stakeholders in the network. Greaves (2007) has emphasized the point that isolating bandwidth management as a purely technical IT issue will mean that any bandwidth man agent can only ever be defensive fire fighting. In actual fact components of bandwidth management may conveniently be classified into three broad categories, namely:

- Techniques and technologies – these are a number of tools and techniques that help network administrators ensure that bandwidth is managed and that policy is enforced;
- Organisational access and management policies – known as policy-based bandwidth management;
- Monitoring- which employs both technical and physical check means to help in the definition and enforcement of policy, faults diagnosis and accurate troubleshooting on the network

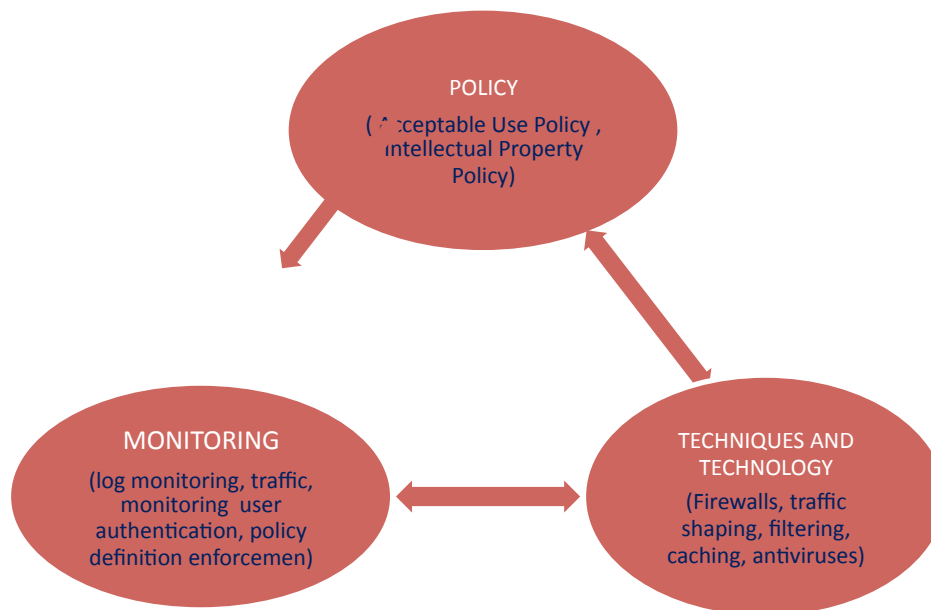


Figure 1: The Critical interdependent components of bandwidth management

It should be noted that policy is an essential component of any bandwidth management strategy. Without it, technical solutions will be difficult to implement and much less effective. Policies are essential in that they provide the framework for defining how a network is to be used and detail how technical solutions should be implemented. Without a policy, users will not understand what we are doing or why, and will complain or subvert our actions instead of helping us to achieve our goal. Policy-based management allows a University to control which network services and resources are available to its users in accordance with its IT strategy. From a policy, an AUP should be developed. The AUP should be a written document that defines acceptable forms of network access, as well as guidelines for how network problems are dealt with, definitions of abuse, and other operational details. The AUP should also include definitions of legal constraints for network users, for example, the exchange of copyrighted material, requesting inappropriate materials, etc. Having a policy makes it much easier to enforce certain types of network behaviour as it will be possible to hold people to a set of agreed rules. These policy rules should then be configured into the various network resources, that is, the actual devices that then implement and enforce the rules.

To sum up the discussion, bandwidth management requires three activities, namely policy, monitoring and implementation of technical solutions. If anyone of these is missing, then, the management of bandwidth is significantly compromised. These activities inform and enforce each other (Rosenberg 2008). Improving the performance of the information delivery chain is urgent if faculty and students are to benefit from the Internet and take part in the international academic community (Rosenberg 2005). No amount of bandwidth is enough to satisfy the demands of an unrestricted user community (Sharma, Kumar & Thakiu 2011). It is therefore critical that bandwidth usage policy stipulates a number of rules that define how bandwidth is to be allocated and prioritised in view of the critical areas of the university's core business. A university wide network access and management policy is needed to help the ITS staff monitor and control the level of traffic that passes down a communications link. Ensuring that bandwidth is available for students and faculty requires policy and commitment from all stakeholders. This study point to the need for universities to recognise the fact that bandwidth is a valuable institutional resource that needs to be managed, conserved and shared as effectively as possible. Instead of simply extending computers and network infrastructure or finding cheaper Internet Service Providers (ISPs), this study proposes an approach to bandwidth management that put emphasis on ways to control and manage the many noncritical bandwidth hungry Internet applications, uses and practices that consume bandwidth. Although such an approach recognises the technical requirements regarding network configurations, its emphasis is on suitable policies and guidelines which encourage proper bandwidth saving behaviour among the users. The strategies should be employed to ensure that high priority applications are carried out as efficiently as possible for the institution to achieve its set targets.

METHODOLOGY

In order to meet the study's objectives, a mixed methods approach was used to gather relevant data. The targeted respondents were personnel from the Information Technology Services department, Computer Centers or other related departments. Principal authorities, including Vice Chancellors, Librarians and Registrars, were also targeted to provide data on ICT governance and policy issues. The targeted universities were selected based on their size and importance.

A two-pronged approach of self-administration of emailed questionnaire and phone interviews were used to gather the relevant data. The questionnaire was sent to the respondents via e-mail. To maximize response rates, several follow-ups on phone calls were made to remind and encourage respondents to complete and return the questionnaire. The questionnaire incorporated a series of questions about campus infrastructure, including the number of computers that were

networked or connected to the Internet, bandwidth management strategies used and the challenges faced. In some institutions the process of completing the questionnaire required a number of formal processes to be carried out, thus hampering the response rate and increasing the turnaround time. Telephone interviews were conducted with four ITS directors, one Vice Chancellor, two Registrars and three Librarians from the four sampled state universities in Zimbabwe. With permission from the interviewees the interviews were recorded to ensure accurate transcription.

RESULTS

The status of Internet access in Universities in Zimbabwe

The state of Internet connectivity at the selected universities can be summarized by three characteristics: too little, too expensive and poorly managed. Access to the Internet was provided to all students and staff via laboratories in various locations in the universities, which included computer laboratories, computer centres and libraries. In addition 3 Out of the 4 universities had a campus wide wireless network. Network services offered included, Internet surfing, accessing electronic databases and journals, e-learning, personal e-mail and file sharing. Students were not charged for Internet access to services such as e-mail, library services and e-learning. It was also noted that students at all the universities would logon to the networks using a generic username and password to access network resources. On some computers, users were not required to logon in order to access network resources. In such a situation it is not possible to identify a user who has a habit of abusing Internet resources.

There were large differences in levels of computer access among the institutions. The highest number of users per computer was 10. The average across the sample was 6.8 users per computer, with 3.5 users per networked computer as the university that had the best ICT resources. However, this is still a high ratio compared to the average students per networked computer ratio of USA institutions, which is thought to be about 3 per computer (Education Week's 2010), and with plans to reach 1:1 by 2012.

Table 1: Current Internet connectivity status

| Network Service | University | | | |
|-----------------------|--------------|--------------|----------------------|----------------------|
| | A | B | C | D |
| No. of Networked PCs | 1450 | 1000 | 400 | 450 |
| No. of Users | 12 000 | 3 500 | 2 560 | 4 500 |
| Size of Bandwidth | 28 Mbps | 22 Mbps | 1 Mbps (256 kbps) | 5 Mbps |
| Type of Internet Link | Fibre Optics | Fibre Optics | VSat Leased Line | Radio/Fibre Optic |

The highest bandwidth reported for the sample was 28 Mbps (both upstream and downstream), roughly equivalent to a low-end broadband residential connection in North America or Europe. However, this was above the minimum 10 Mbps by year 2008 as recommended to all African Vice Chancellors in 2007 (SARUA 2006). The 3 out of the 4 universities used fibre optics for their Internet connectivity. It was disheartening to note that one of the universities was still using a dial-up connection for Internet connectivity. Institutions with fibre connection tended to have the highest connectivity, while those with a dial-up connections have the lowest capacity.

Table 1 summarises the Internet connectivity situation at the four universities.

Bandwidth Utilisation Pattern

Bandwidth utilisation pattern for one of the universities (A) indicated that the university working hours start from 8:00 am to 10:00pm. Bandwidth utilisation during this period was almost 100% as indicated in figure 2 and 3 below. It was also noted that bandwidth availability was fairly good at all the universities, for example as indicated in figure 2 and 3 there were only very short spaces of time when connectivity was disrupted. This was observed to be the short time during the change over from normal electrical power to generator. At all the universities standby generators were in place to curb the electricity power cuts which were experienced in the country.

Figures 2 and 3 show the bandwidth utilisation pattern at one of the universities.

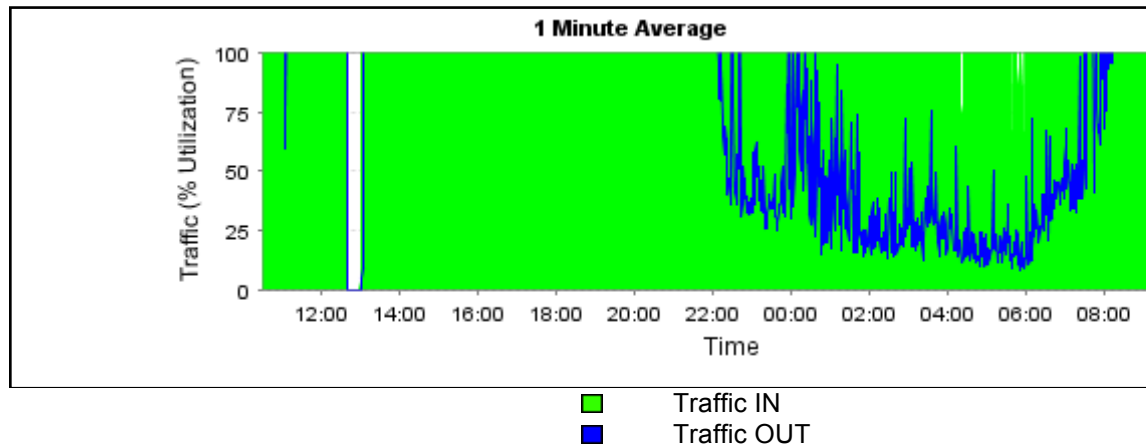


Figure 2: Bandwidth utilisation graph

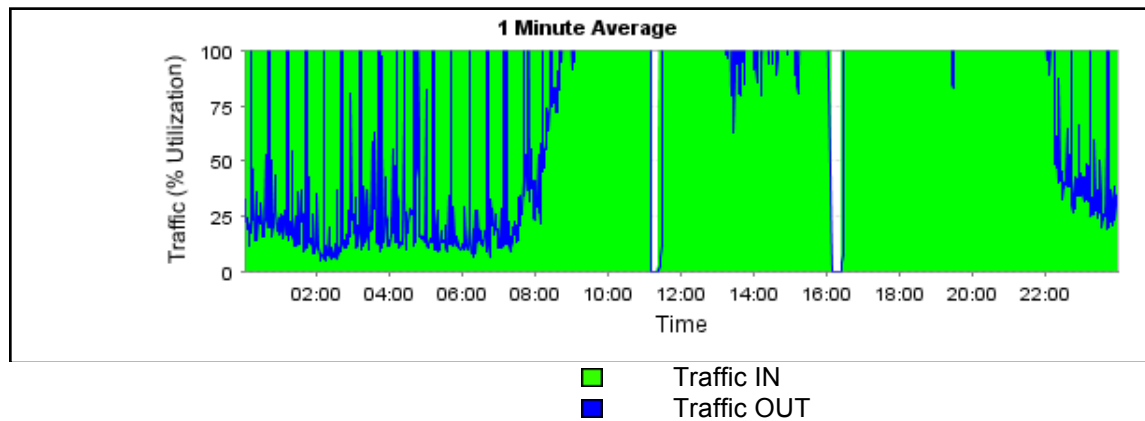


Figure 3: Bandwidth utilisation graph

Bandwidth Management Strategies Employed

The data collected show that there was a limited range of bandwidth management techniques employed by universities in Zimbabwe. The ITS directors (2 out of 4) who indicated that they practiced bandwidth management reported that they used the following techniques to manage their bandwidth:

- Web caching
- Web access controls
- Port and application blocking
- Use of monitoring and reporting tools
- Use of antivirus
- Use of spam filters

One of the ITS directors indicated that they used the following the following strategies to control and monitor the levels of unwanted traffic on their network:

- limiting access to certain users
- limiting access to certain Web sites
- limiting access to certain file types or materials

The data collected show that universities were not taking bandwidth management seriously. This was evidenced by the lack of a bandwidth management policy at all the universities. Only two ITS directors pointed out that they were still at the planning stage of bandwidth management policy and draft copies of the policy were in place but implementation had not taken off the ground. Three out of the four ITS directors reported that they did not have staff with knowledge and skills to practice bandwidth management, in addition to the lack of relevant technologies to implement effective bandwidth management strategies. All the ITS directors indicated that technical solutions to bandwidth management were far beyond the reach of their cash stricken institutions. These were reported to be very expensive and unavailable on the local market. With regards to AUP, all the four universities had no written down policy document to govern the use of network resources. There was not any type of agreement signed between the users and university that they had to follow any policy guidelines, rules and restrictions. It was therefore difficult to institute any restrictions and legal action against network abusers. Only one university reported the existence of a policy on Free and Open Source Software (FOSS) which they said had helped to eliminate unwanted traffic introduced through viruses for example. The results are summarised in table 2.

Table 2: ICT Policies and Plans breakdown

| Type of Policy/ Plan | A | B | C | D |
|------------------------------------|-------------|-------------|-------------|-------------|
| ICT Committee | Present | Present | Present | Present |
| ICT strategic plan | Present | Present | Present | Present |
| ICT policy | Not Present | Not Present | Not Present | Not Present |
| AUP | Not Present | Not Present | Not Present | Not Present |
| Bandwidth Management Policy | Not Present | Not Present | Not Present | Not Present |
| Policy on Use of FOSS | Present | Not Present | Not Present | Not Present |

Although two IT directors indicated that they monitored their bandwidth, none of them could provide basic usage figures, indicating that monitoring was sporadic. Observations were that current bandwidth use reached saturation levels during normal working hours, but traffic was reduced at night and during weekends (see figure 2 and 3).

Challenges of Bandwidth Management

Universities in Zimbabwe were faced with major obstacles in their use of networked information resources. The major challenge reported by all the respondents, from both questionnaires and interviews, was that of a disproportionately high cost of bandwidth, which made it practically difficult for universities to significantly expand their Internet bandwidth.

All the respondents to the questionnaire concurred that the following were their day to day challenges in the utilisation of bandwidth;

- Too many users on the network
- Viruses
- Uncontrolled downloads
- Unreliable Internet service provider
- Higher demand compared to available bandwidth
- Different user bandwidth requirements
- Technical breakdowns
- Lack of administrative support

At university A, where there was a deliberate policy to use open source solutions, the ITS director pointed out that there was a general user resistance in using open source software and other low bandwidth utilising technologies. The director also pointed out that another challenge at university level is presented by IT savvy students especially those who specialise in computer related areas who always find some solutions to bypass any restrictions that may be imposed by technical solutions. All the ITS directors concurred that use of bandwidth hungry applications such as streaming audio/video application, social media, etc. was high among the student population.

DISCUSSION

A university Internet connection is intended to provide a technology resource for the university community of scholarship for use in the pursuit of the mission of the university. It is an expensive resource and its utilization must be managed in such a way that it is appropriately used to support the academic activities of the university community. The main challenge relating to bandwidth management in universities in Zimbabwe is lack of awareness of the need to manage bandwidth.

There is relatively little appreciation and understanding about the importance of managing bandwidth for the health of the institution. With a congested network, access to Internet resources for which the university pays is rendered ineffective, with the result that the investment in the university is not used as efficiently as it should. INASP(2003) notes that to optimise Internet bandwidth universities must recognize that bandwidth is a valuable institutional resource or asset that needs to be managed, conserved, and shared as effectively as possible and that the institutions' management must make bandwidth management a priority. The growing demands for Internet resources over a limited and expensive bandwidth demand that universities in Zimbabwe develop strategic controls to build a manageable network. However, the results of this study show that there is limited bandwidth management activities carried out at the selected universities in Zimbabwe. Lack of bandwidth management and monitoring usually allows a minority to consume the majority of an institution's bandwidth. A minority group of knowledgeable users who usually ignore voluntary guidelines will use a disproportionate share of the university's Internet connection if they are not controlled. Although some universities were employing spam filters together with antivirus software and vulnerability scanning for incoming files as bandwidth management solutions, results of the study show that these strategies are not effectively solving the problem of slow Internet connectivity in universities.

As reported by ITS directors, technical solutions to bandwidth management are beyond the reach of universities in Zimbabwe, making the establishment of a responsible user base through education and enforcement of Acceptable Use Policies (AUP) the focus of universities in Zimbabwe. In fact, this is more practical considering the fact that much of what is called bandwidth management has to do with managing people and changing their netiquette. Literature has shown that although policy may ban or discourage a certain type of Internet usage, in practice it can be difficult to completely enforce that policy purely by Quality of Service means (ATICS 2006, Moll 2005, Greaves 2005). For example, an institution may have a policy of limiting the use of file sharing, but determined users can channel file sharing over other protocols such as HTTP, which is difficult to detect. Technical solutions will not be effective on their own. Greaves (2005) emphasises the point that isolating bandwidth management as a purely technical exercise will mean that bandwidth management will become a defensive firefighting strategy. Effective bandwidth management can only happen by applying a combination of technical computer skills, effective network monitoring, and a sensible policy that is understood by all users (Flickenger, Belcher, Canessa & Zennaro 2006).

This study argues that the fundamental step towards effective bandwidth management is achieved by managing user's net behavior. For example, this study has established that Internet is not used during the night and weekends, users may take advantage of such times to download large files. Downloads which have been identified as a major challenge may be minimized if users are educated that turning off the automatic downloading of images in their browser makes the pages load much faster, that opening two browser windows and reading one page while the next downloads makes them more productive. In this situation, user education is far more productive than technical solutions. According to Flickenger, Belcher, Canessa and Zennaro (2006) user education is critical to every stage of implementing a plan to manage bandwidth. They observe that while users can be forced to adhere to certain behaviour patterns, it is always far easier to implement a plan with their voluntary compliance. The challenge is how to bring such a plan into being. Nevertheless, the big lesson learned from Carnegie Mellon University was that users were willing to change their behaviour, and that without their cooperation, technical solutions alone could not solve the problem. However, it is noted that if we simply order people to change their behaviour, little is likely to change and that when we install technical hurdles to try to force them to change; they will simply find a way around the obstacles. It can therefore be concluded that it is worth the effort to work with users to manage the bandwidth at an institution like a university.

The biggest challenge is to raise awareness of the importance of managing bandwidth. The lack of awareness is reflected in the relatively low adoption of AUP in universities. What makes the situation at the four universities worse is the fact that there was no written down policy to govern the use of the Internet at each of them. Without policy it is impossible to manage key aspects of bandwidth use. Policy is an enabling element of higher education management, some things are denied in order to make other things possible. Nevertheless, there is no out-the-box one-size-fits-all solution. Each institution will have to develop policy, enforcement and communication strategies that fit its unique circumstances.

It must therefore be recognised that without an agreed AUP, for example, no amount of bandwidth will ever be enough to satisfy the demands of an unrestricted user community. The first step towards creating a responsible user base is by having a sensible AUP to which users can subscribe. All stakeholders, especially the users, need to understand and appreciate the need to conserve and bandwidth in order to improve on the speed of Internet access at their institution. Effective bandwidth management is only possible with support from all stakeholders, especially the users, network administrators and university principal management. Furthermore, senior management has to provide leadership and strategic direction that create a supportive environment for the enforcement of policy requirements.

The challenge to bandwidth management is further worsened by the fact that lack of monitoring was shown to be a consistent problem during the research into bandwidth management. Monitoring is important for defining and enforcing policy. Network managers should continuously monitor network traffic and users' behavior both technically and physically as well as analyzing web applications that eat valuable bandwidth. Before an institution can decide how to address the problem of reducing bandwidth demands, it is important to be aware of how bandwidth is being consumed at the moment. Without monitoring, IT staff will not have a good understanding of the traffic on their networks and will not be able to identify the root cause of many Internet connectivity problems. Network monitoring informs the process of creating an enforceable policy that reflects the actual needs of the user group. At all the 4 universities it is only possible to get the bandwidth usage history per IP address since users did not logon to the network using a unique user identity and password in order to access network resources. Authentication and user identification is not possible. This scenario results in a situation where it is difficult to identify users who abuse bandwidth and other network resources. Furthermore, it was also noted that ITS staff at the four universities had no mandate from their institutions that would allow them to employ bandwidth management strategies that would prioritise academic usage of the Internet.

Challenges: The universities' dilemma

While network monitoring for bandwidth management is appropriate, monitoring of individuals' activities does not comport with higher education values. In a university setting, we are expected to provide a lot of freedom in what we allow on the network, permitting the broadest possibility of network traffic without opening the network to compromise. This is a slippery slope! While network monitoring is appropriate for certain purposes such as security and bandwidth management, the surveillance of individuals' Internet communications implicates important rights, and raises questions about the appropriate role of higher education institutions in policing private behaviour. As noted in the *Sweezy v. New Hampshire*, case in O'Nei (2008) teachers and students must always remain free to inquire, to study and to evaluate, to gain new maturity and understanding; otherwise our civilization will stagnate and die. Monitoring the content of communications is fundamentally incompatible with the mission of educational institutions to foster critical thinking and exploration (The Electronic Privacy Information Center (EPIC), 2002). EPIC (2002) argues that monitoring will stifle the creative spirit which is very critical on student learning. Furthermore, EPIC (2002) observes that monitoring irritates the learners and can stifle creativity that must thrive in educational settings. Because individuals at institutions of higher

learning must always remain free to inquire, colleges and universities are not the place for technological restrictions on communication. Institutions of higher education should not practice content monitoring, an approach that the controlled environments of corporate workplaces and kindergartens have adopted.

All stakeholders of any university, including students, must be involved in a process that recognizes the legitimate concerns of the need to use bandwidth wisely without unduly hindering academic freedom, privacy, and fair use rights. As Rezmierski and Soules (2000) have noted, for a policy to be effective in guiding university community behaviours, it needs to reflect the full range of the community's values. The policy must be understood and embraced by all the community members, and must reinforce the most important values and the mission of the institution as a whole. An effective policy requires campus-wide discussion and the involvement of each of the major constituencies of the community.

CONCLUSIONS AND RECOMMENDATIONS

Lack of appropriate bandwidth management is preventing the productive use of the Internet at the universities, which in turn yields to low quality academic and research work. Managing bandwidth to provide quality of services for university mission critical applications is important since it is not practical to meet the increased demand for bandwidth by simply buying more. In the ideal world with informed and technically competent users who are motivated by enlightened self-interest, we would be able to leave users to manage their own traffic, in the spirit of the free and open philosophy upon which the Internet was founded. Nevertheless, the problem is that when we do not manage traffic, the result is that a considerable amount of bandwidth will be used for things that are not related to the mission of the university. However, it is sad to note that although it is common knowledge that an effective strategy for bandwidth management is a key feature to increasing bandwidth availability for research and education purposes, the majority of universities in Zimbabwe take very little or no actions to manage their bandwidth usage. The results of this study have demonstrated that more awareness education on bandwidth management is needed for universities to make it a priority. Increasing bandwidth without adequate network management is wasteful and reduces its value. The absence of effective bandwidth management strategies poses serious challenges for almost all universities in Zimbabwe.

It should be noted that increasing the size of bandwidth and the provision of technical tools alone is not sufficient for effective bandwidth management. There is now an increased need for IT directors and university administrators to balance increased bandwidth access demands with investment in bandwidth management strategies. There is therefore urgent need for Universities in Zimbabwe to proactively implement policy based bandwidth management solutions. Most importantly, the university's policy needs to be understood and enforced. The policy must be enforced, and violations must have real consequences. This should be done via existing channels for staff and student discipline, so that it is given the same weight as other infringements of rules. The idea however is not to set rules and regulation that will inhibit the productive use of the Internet. These bandwidth management strategies should be designed to ensure that university campuses have adequate bandwidth to meet their educational and research requirements. The motive of any university's bandwidth management strategy should be to optimize use of shared resources amicably between users rather than impose restrictions.

Network managers should also note that although policy is a key tool in the effort to keep the Internet free and fast, even the best policy has no value unless it is communicated and enforced. There is need to have a well coordinated system among all stakeholders, university management, IT staff, researchers and students to ensure that there is a common understanding of the need to adhere to best practices of Internet usage. The policy development process must be consultative

supported and led from the top. Stakeholders must agree on which services will receive high priority and which will receive low priority or be discarded. This should be done using university committee systems and governance groups comprising of students, faculty members, ITS staff and university administrators, to discuss bandwidth management alternatives and set policy.

As such the study recommends the following:

- The formulation of a university wide IT policy, which will provide guidance on user access and usage policy. The policy should be used to determine and govern issues such as:
 1. monitoring Internet use and enforcing the appropriate use of the Internet
 2. use of the Internet by those employees that do not require it for their work
 3. downloading and installation of “Internet enhancing” software
 4. keeping all campus computers free of virus and spam
- Awareness education programmes should be used to address issues such as;
 1. encouraging positive behaviour from users,
 2. encouraging appropriate use, the importance of using antivirus software,
 3. establishing rules and securing agreements as to what constitutes appropriate use of the Internet bandwidth,
 4. informing users about appropriate use policies and
 5. providing training to users as to how to effectively use the Internet and conserve bandwidth

A policy must be continually communicated to stakeholders in a meaningful way, especially as many stakeholders will not be familiar with the technical jargon that such a policy will inevitably contain. Communication will also require ongoing attention, since each year brings a new cohort of students. The education programme should focus on talking with users about fairness, why all users need adequate bandwidth to do their research, the impact of bandwidth consumption on the cost of tuition and the need for accountability in the use of the Internet . The overall aim of the user education program should focus on the net gains for the campus community of using bandwidth responsibly, the importance of adherence to best practices and good behaviour when using the Internet .

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