Optimization Technologies for Low-Bandwidth Networks

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Abstract: *One measure of the growing disparity between the developed and developing worlds is the speed of the Internet. For example, the speeds of connections from North America to Africa are slower than those to Europe by a factor of 50. The reasons for this disparity include the availability of Internet access only via slow satellite connections, and the lack of communications infrastructure in the remote parts of the world. Bandwidth and computing equipment are expensive as a result of weak currencies, high transport costs, small budgets and unreasonable tariffs. Bandwidth in some developing countries can be so costly that even their prime universities cannot afford speeds equivalent to the average western household with an ADSL connection. Thus universities and other institutions cannot afford a decent link, or are simply unaware of existing alternatives. This paper attempts to provide practical information on how to gain the largest benefit from existing connections to the Internet, by exposing readers to thelatest techniques to optimize the use of low-bandwidth network connections. This study has for the years 2005 and 2008 with the beginning of the implementation of the Sudanese Universities Network to measure the performance of the network. Byapplying optimization techniques, the effectiveness of available connections can be significantly improved. Access to more bandwidth will facilitate better exchange of scientific information, data and literature among researchers all over the world.*
Keywords: *Bandwidth, throughput, latency, speed, Policy, monitoring &analysis, and implementation.*

I.   Introduction

The Internet has invaded many aspects of daily life. What was once an obscure scientific research tool has blossomed into a communications platform used by hundreds of millions of people. Telecom providers use the Internet to carry critical voice communications. Banking institutions use it to provide access to account services and market trading. Airline tickets, hotel reservations, and car rentals can all be booked with a click of the mouse. More users than ever depend on the Internet to connect with family and colleagues using email, Instant messaging, Voice over IP, photo and video sharing services, and online journals. Children born in the last ten years have grown up in a time when the Internet has always been available.[1]

What actually causes a slow Internet connection?

Obviously, the capacity of given connection is finite, so if too many people request information at once, then someone will have to wait. In an ideal world, organizations would simply order more bandwidth to accommodate the increased traffic. But as we all know, Internet access costs money, and most organizations do not have infinite Budgets.

Principles: Bandwidth, throughput, latency, and speed are a few technical words used to describe how fast an Internet connection may go.[3]
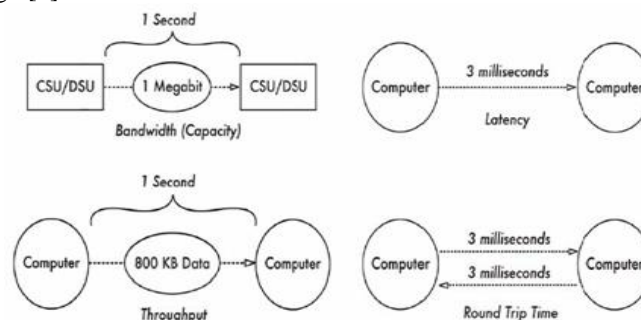

Figure 1: Bandwidth, Capacity, Throughput, Latency, and Round Trip Time.

Problem definition

"How to fix your slow Internet connection and gain the largest possible benefit from your connection to the Internet. By applying the optimization techniques and monitoring", and I discuss one case study of Sudanese university.

Objectives

This paper attempts to provide practical information on how to gain the largest benefit from existing connections to the Internet, by exposing us to the latest techniques to optimize the use of low-Bandwidth network connections. . so that eliminating wasted bandwidth, the cost of operating your network connection will be reduced, and the usability of the network will be improved.

II. Methodology

In order to effectively manage a network connection of any size, you will need to take a multifaceted approach that includes effective network monitoring, a sensible policy that defines acceptable behavior, and a solid implementation that enforces these rules. Each component is important for effective bandwidth Management in any network that consists of more than a few users. In this paper use this component to solve the problem[4]
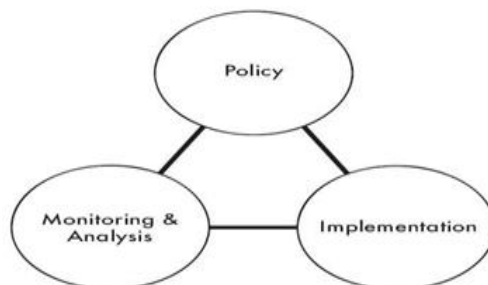
Figure 2: Policy, Monitoring & Analysis, and Implementation are three critical (and interdependent) components of bandwidth management.

1: The adopted Policy

Is a statement of opinions, intentions, actions and procedures that guide the overall use of the network. An acceptable use policy is a subset of this. It 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 policy also typically includes definitions of legal constraints for network users (such as the exchange of copyrighted material, requesting inappropriate materials, etc.). [2]

2: Network monitoring

Is the ongoing process of collecting information about various aspects of your network operations. By carefully analyzing this data, you can identify faults, find cases of waste and unauthorized access, and spot trends that may indicate future problems.[2]

3: Implementation

Is the step of implementing filtering, caching, and other technologies within your network to help bring actual usage in line with policy. The actions you need to take are indicated by the data collected through monitoring and analysis, and are constrained by the network policy. Many people expect to begin the task of bandwidth management by starting with this step. But without good monitoring techniques, you are effectively blind to the problem.

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. This research is designed to be used as a guide to anyone who needs to tackle this difficult problem.

The implementation will show the essential technical components (technical constraints) that should be in place in every network connected to the Internet. These techniques will allow you to limit, priorities, and optimise the flow of information between the Internet and your users.

We can take**Suin Project** to explore agood idea of how we implement to achieve experiences to solve the problem of law bandwidth , we take a Suin Project as important project for higher education institution in Sudan .[3]

Case Study:
The Sudanese Universities Information Network

The overall goal of this project is to provide connectivity among the Sudanese educational institutions, increase sharing of knowledge, help universities build their information infrastructure, and extend the value of digital libraries.
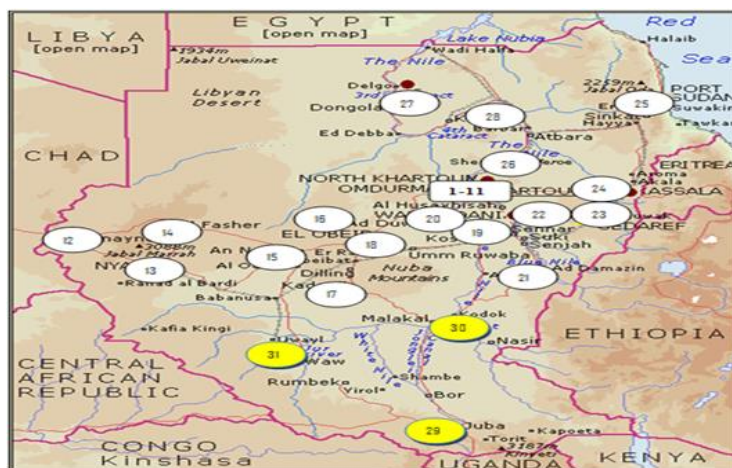
Figure 3: The geographical distribution of SUIN universities.

Design and Implementation of SUIN

By the end of 2005 **phase I** started , all universities were connected by 128 kbps data link using the Frame Relay technology to a central router at the University of Khartoum. The network was connected to the Internet via 4 Mbps link, using the DSL technology.Currently, there are 31 members directly connected to the main node in Khartoum‹The service is provided by Sudatel which is the oldest and largest private telecom operator in Sudan. The project started with this very low connectivity speed because of the low budget available at that time.
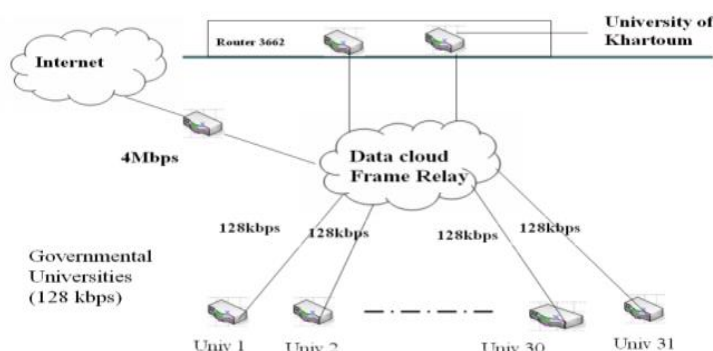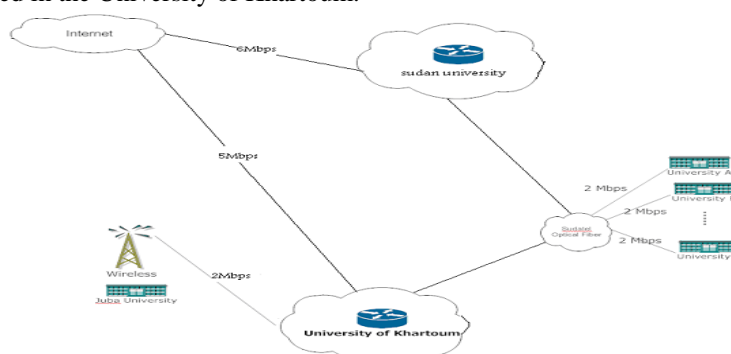

Figure 4: shows the topology of the network in phase I.

In May 2008 **phase II**started , ten universities were connected to the leased optical fiber (SDH). Eight of those universities are located in Khartoum and two are located in the central states (Gazira and White Nile). Links of 2 Mbps are provided to each university for connectivity, and 15 Mbps are provided for the Internet bandwidth . According to the near future plan each university will be provided with 5Mbps for the Internet. The network is centralized in the University of Khartoum.

Figure5: shows the topology of the network in phase II.

Problem Statement:

MOHE is member of Sudanese Universities Information Network (SUIN).It connected to network by using SHDSL technology with a bandwidth of 1Mbps.The network consist of about 245 machines. They use one proxy server to gain access to the internet.

The network is facing a problem of a low available bandwidth (connections are very expensive in most parts of the world, and it is often costly and difficult to add additional network capacity), and impact of spam and viruses

The Proposed Solution:

Network monitoring and Analysis Is the ongoing process of collecting information about various aspects of your network operations. By carefully analyzing this data, you can identify faults, find cases of waste and unauthorized access, and spot trends that may indicate future problems.

An analysis of each institution's traffic behavior was made using graphical packet analyzer, that changes to the network could be monitored for their effects

These tools can help you answer critical questions, such as:

- What are the most popular services used on the network?
- Who are the heaviest network users?
- At what time of the day is the network most utilized?
- What sites do your users frequent?
- Is the amount of inbound or outbound traffic close to our available network capacity?
- Are there indications of an unusual network situation that is consuming bandwidth or causing other problems?
- Is our Internet Service Provider (ISP) providing the level of service that we are paying for? This should be answered in terms of available bandwidth, packet loss, latency, and overall availability.

We develop the monitoring system using vb program to show the traffic in the network and decide what we do
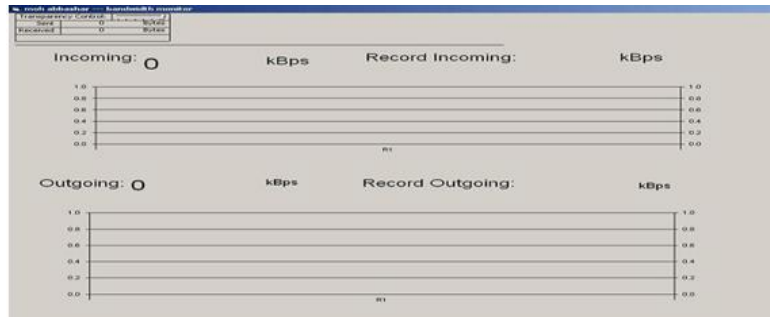
Figure 6: Software Interface

Output:
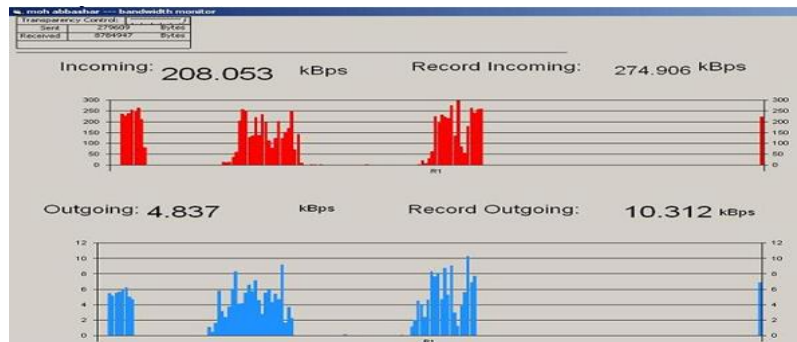
Figure 7 :monitor Result.

Policy

The importance of policyan abundance of bandwidth enables electronic collaboration, access to informational resources, rapid and effective communication, and grants membership to a global community. An absence of bandwidth prevents access to the aforementioned global community, restricts communications, and slows the speed at which information travels across the network. Therefore, bandwidth is probably the single most critical resource at the disposal of a modern organisation.

Characteristics of good policy:-

• **Good policy has an enabling purpose**. The aims of the policy should be clear and apply to all users. If it is going to restrict user behaviour, then all users need to know why that is. The aims outlined in the the policy should not be a technical statement (e.g., "this policy exists to optimise the flow of data essential for our core business objectives over our network circuit.").

• **Good policy has clear ownership.** Ownership of the policy should be clea and mandated from an appropriate level within the organization(most senior management of the organisation). Ideally, this level will be that which is representative of all members of the organization and not be seen as being imposed upon users by one part of the organisation.

• **Good policy is short and clear.** If we want our users to abide by the policy, then they need to be able to read it(avoid technical jargon wherever possible). If we want them to buy into the policy (e.g., have all new students sign an agreement to abide by the Acceptable Use Policy (AUP)), then it must be easy for them to read and understand.

• **Good policy is enforced**. enforcement is usually only an issue for a very small number of users who are disproportionately using your bandwidth. Evidence shows that enforcement can be achieved at both a technical level (e.g., blocking users or traffic) and a human level (sending a warning email). The simple human level warning is often effective.

• **Good policy is adaptable.** No policy is perfect; it may need revisions, particularly as the network grows.

➢ **The importance of user education**

The actions of your users will determine your bandwidth utilisation . Therefore, your users should be informed of the rights and obligations that govern network use.

o The 5/50 rule
o Providing feedback to users about network load
o General good practices.

The 5/50 rule:

The majority of users make light use of network resources(check their email and browse a few web pages) without making excessive use of the network. However, there are always a few users who will use all available bandwidth, both inbound and outbound, by running servers, peer-to-peer file sharing programs, video streams, and other bandwidth intensive applications. Those are the circumstances where the 5/50 rule comes into play. By focusing on the 5% of users who typically consume 50% of the bandwidth, you can make a huge impact on network performance with less effort.

Once you have identified problem users(by monitoring), you should inform them that their usage deviates from that which is stated as acceptable by the network access policy.

Providing feedback to users about network load:

If users know there is network congestion, they tend to cut down on their usage,that will make the network is better for everyone. Without that feedback, users tend to think that the network is "broken" and may inadvertently increase the network load. We remember one method for example you can use to communicate the state of the network to your users called (Public utilisation graphs)

Public utilisation graphs It is one of showing network congestion method to your users, that is simply to publish your utilization graphs on a web server. Even when the Internet connection is experiencing heavy use, the monitoring server will be available . This will show all the lag is caused by too much network access. By including individual user data, as well as aggregated throughput statistics, you can encourage people to remind their peers that bandwidth is limited. Some sites even post a "top ten" or "top 100" list of excessive bandwidth users, aggregated daily or weekly. If your name appears on that list, you can be sure that your friends and colleagues will have a few words for you. This method can be even more effective than receiving a phone call from the network administrator.

You can set the utilization graphs as the default home page , This helps to serve as a constant reminder for users that their actions have a direct impact on their colleagues' ability to access Internet resources.

General good practices:
There are several techniques that your users can implement on their own to help keep bandwidth utilisation to a minimum.

➢ **Optimise your web browser**
A:Disablebandwidth-hungry plugins like Java and Flash.
Since the vast majority of Java and Flash applications are simple animations, games, and videos, there is rarely any need to download them except for entertainment purposes, so you simply disabled it

B: Disable automatic updates.
While keeping your browser software up-todate is vitally important from a security point of view, updating in automatic way may waste significant bandwidth at peak times.

C: Increase the size of the local cache.
If there are sufficient resources on the local machine, increase the browser size. More is generally better, but a cache of several hundred megabytes is usually reasonable.

D: Disable pop-ups.
Pop-up windows are nearly always unwanted advertisements containing large images or flash movies, and will automatically consume significantamounts of unintentionally requested bandwidth

F: Use ad blocking software.
By blocking ads before you download them,you can save bandwidth and reduce user frustration.

G: Install anti-spyware tools
Malicious sites may install spyware programs that consume bandwidth and introduce security problems.Usinga spyware detection and removal tool will keep these problems to aminimum.

H: Use Mozilla Firefox instead of Internet Explorer.
Although it is the default browser on most Windows boxes, IE is a notorious attack point for spyware and viruses, Mozilla Firefox is an open source project,it has a very large and flexible set of extensions that allow you to configure and optimise just about every aspect of how the browser works.

➢ **Optimise your email**
There are many steps you can take as a user to make your email work better too.

A: Don't use web mail.
Sites such as Hotmail, Gmail, and Yahoo! Mail use significantly more bandwidth than do traditional email services. With graphics, advertisements, and an HTML interface, an individual email may represent thousands of times the number of bytes of the equivalent text email. If your network provides email services (via Mozilla Thunderbird, MS Outlook, or another email client), then use them

B: Send emails in plain text, not HTML.
HTML emails are bigger than their equivalents in plain text, so it is preferable to send plain text emails to reduce bandwidth requirements. Most email clients let you set plain text as the default format, and/or on a per email basis. As well as reducing the amount of bandwidth needed

C: Limit the use of attachments.
While it is possible to send huge files through email, the protocol wasn't really designed for this use. Instead of sending a large file to a group of people, post the file to a web server and send the link instead. If you must include an attachment, make it as small as possible. You can use a compression utility to reduce the size of the file

E: Use IMAP instead of POP
The IMAP protocol makes much more efficient use of network bandwidth by using a caching system that only downloads messages when needed. The POP protocol downloads all email messages as they are received, whether they are opened or not. If possible, use IMAP instead of POP. Your network administrator should be able to tell you if an IMAP server is available. This is especially critical when accessing your email over a low-bandwidth link.

One last word about attachments Consider what happens when you send a file attachment to a large group of

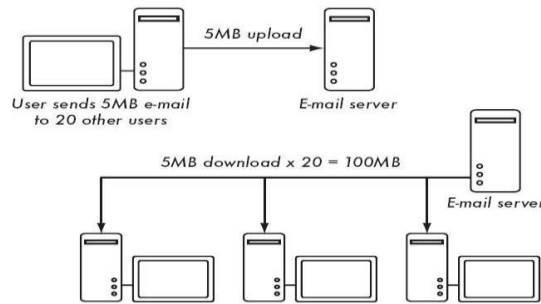people. The flow of information may look something like Figure :

Figure 8: Utilization is very high as users download the attachment.

 A single unnecessary email attachment can quickly add up to hundreds of megabytes of wasted bandwidth as users forward it to each other.

➢ **Essential services**
you can implement hard restrictions on the flow of network traffic.

A firewall
        A firewall is a part of a computer system or network that is designed to block unauthorized access while permitting authorized communications. it can be implemented in either hardware or software, or a combination of both. and frequently used to prevent unauthorized Internet users from accessing private networks connected to the Internet, especially <u>intranets</u>. All messages entering or leaving the <u>intranet</u> pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria.
we need a firewall To prevent certain types of data from getting in or out of particular areas and Security between the outside world and your network, especially protection from most Internet security threats

Caching proxy server
        a cache is a collection of data duplicating original values stored elsewhere or computed earlier, where the original data is expensive to fetch , compared to the cost of reading the cache. In other words,
  Once the data is stored in the cache, it can be used in the future by accessing the cached copy rather than re-fetching or recomputing the original data.

We use the caching server
⬜To reduce latency: Because the request is satisfied from the client instead of the origin server, it takes less time for the client to get the object.
⬜To reduce traffic: Because each object is only gotten once from the server, it reduces the amount of bandwith used by a client.
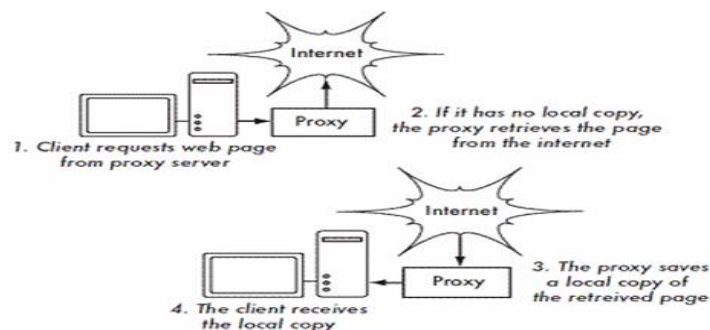

Figure 9 :proxy servers make requests on behalf of aclients program , they may implement authentication or caching

Software Updates
        Most packages or operating systems require software updates. If you look at the output from your proxy log file analysis, it will become apparent that one or two software update sites contribute significantly to your bandwidth consumption. While a caching proxy will take some of the load off, you can proactively populate a local mirror with software updates, and redirect your users there. Some common applications that update themselves are:

• **Windows.** Windows updates are a common problem, since machines asynchronously decide when to update themselves, and download redundant copies
of the same patches. Fortunately, you can to set up a **Microsoft Windows Server Update Services** (**WSUS**) mirror on your local network. Clientscan then be made to point to the local server for updates through a simpleregistry entry. Full details on setting up your own Windows Update Servercan be found at http://www.microsoft.com/wsus.

• **Adobe software.** If you have Adobe Acrobat installed on several machines, it will frequently look for and download updates. Keep local, up to date copies and encourage users to disable automatic updates.

Web Design Guidelines for Low Bandwidth
   These guidelines should help you design and build websites that are fast, easy to use and work over low bandwidth connections.
The Parameters We need to make pages load fast, but how fast?
In summary the golden rules are:

1\pages must load within 10 seconds

2\Incrementally displayed pages must show useful content within 2 seconds and complete loading within 30 seconds.
Page loading speed is determined by the size of the page, the number and size of external files it references (JavaScript, style sheets, images and multimedia), and two properties of the user's Internet connection (bandwidth and latency).

3\How large can pages be and still load within 10 seconds
The quick answer is 25kB.
The size depends on the available bandwidth. It is hard to make a good estimate of available bandwidth

4\ Page Size Limits
 Taking into consideration the desired response times at 20kbps gives us the following upper limits on page size:

Page Type	Size
non-incrementally loading page (10 seconds)	**25kB**
incrementally loading page (30 seconds)	**75kB**with useful content within first 5kB

Table1: Page Size
        These limits are for the total page including images, external JavaScript files and external CSS files. Sharing images, script files and CSS files between pages is encouraged, as it allows them to be cached by the user's browser and reduces the loading time of subsequent pages.

5\ Size Indicators
        Any object over 75kB, such as an image or PDF document, could take upwards of 30 seconds to load. Usability research suggests that users will often abandon processes that take more than 30 seconds without feedback. All links to objects over 75kB should, at the very least, be clearly labeled with the size of the object, for example: Report on PDF Optimisation (237 kB)

6\ **Use External Style Sheets Rather than Embedding CSS in the Page**
        In general, embedding CSS in pages should be avoided, Instead, an external style sheet should be used. If you include the same external, static style sheet file in each page, it will be cached by the web browser and need only be downloaded once. This also helps to apply a consistent style across a whole website with minimal effort.

7\ Be Cache-able
Allow browsers to keep a local copy of, or **"cache"**, your pages

8\Put Useful Items First
        Put main navigation items at the top of each page so they load and display first. Make your pages useful even before they finish loading.

III. Recommendations

- Make bandwidth management a priority. Askquestions concerning Internet and network usage, security, and user behaviour. Reward staff thatinstall the applications that help to conserve and share this scarce resource.
- Be safe. Insist on strong network and serversecurity, firewalls, and virus protection.
- Encourage positive behaviour. Devise a usagepolicy to be signed by all users before they use the Internet. This identifies good practices andappropriate 'netiquette' and it sets out procedures to be followed. It should be relevant to the averageuser and it should be enforced. The existence of such a policy (which explains that browsing andother Internet uses can be monitored), can often be a sufficient 'scare factor' to quell selfish orillegal behavior.
- Monitor the IT team. Sometimes the IT experts arethemselves the biggest abusers of bandwidth. Competent and dedicated IT personnel areessential, not only for normal ICT functions, but also to keep bandwidth use under control. Morebroadly, a representative high level governance mechanism or committee can be used o setoverall ICT policy goals, directions, and priorities.
- Give everyone an identity. Tracking usage requiresthat each user of the network have an individual identity or logon that confers rights andresponsibilities. It is a relatively small step to also provide each with a unique local email address aswell as efficient ways to access it from remote locations. Providing such a facility will help toreduce the use of large bandwidth consumers like hotmail and yahoo.
- Evaluate connection options regularly. Bandwidthbecomes cheaper every year. As prices go down, upgrades may enable a university to provide abetter Internet service (and to make it available to more users). Moving to another provider or renegotiatingcontracts may provide more bandwidth at lower cost.
- Join forces. Explore network integration – createnetworks between academic institutions within the country that allow for joint bandwidth purchasing,help to keep local traffic local.

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