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The Future

"Predicting the future is always difficult and is no less so when the Internet is involved," wrote Dr. Jon Knight from Loughborough University in an article published in 2003. "Protocols and technologies appear and achieve widespread use at an alarming rate and much of what is now commonplace was unheard of or only in research laboratories five years ago." Although there are these difficulties in prediction, the development and expansion of current technologies can be analysed for their future bandwidth management implications.

Bandwidth consuming technologies

Among these rapidly-growing Internet technologies is peer-to-peer (P2P) file-sharing, which allows users from around the world to connect to each other and trade items such as music and video files. This was initially made popular in 1999 by the online service Napster, which subsequently lost a high-profile legal battle over copyright violations. However, P2P technologies now have increasing support from large, well-known companies. For example, Warner Bros. announced in 2006 that they would sell some of their films and TV shows using the popular BitTorrent file-sharing system.

This may have an interesting effect on bandwidth management and usage at institutions around the world. For example, many schools and universities have banned or limited the use of P2P programs on their networks, partly because they consume large amounts of bandwidth, and also because they are often used to trade copyrighted files illegally. With the rise in the number of legal, paid-for services that use P2P technologies, the justification for banning file-sharing entirely is no longer so clear.

The streaming of audio and video is becoming increasingly popular, and uses large amounts of bandwidth in comparison to traditional text-only media. Voice

over IP (VoIP) allows telephone calls to be made over the Internet at relatively low cost, and could foreseeably replace current telecommunication systems. Companies such as Skype have established well-known services in this area. Downloading live television broadcasts from Web sites (such as the BBC's) is also becoming common. In addition to causing a heavy load on the network, streaming technologies need a stable, reliable connection. As institutional VoIP usage is likely to increase to the point of being an essential service, this will place a great demand for effective bandwidth management.

A definite trend is continuing towards multimedia websites, which contain bandwidth-hungry images, video, animations, and interactive content. This puts increasing demands on Internet connections, resulting in slower downloads and decreased usability on saturated connections. Bandwidth management technologies will have to adapt to this change, employing new caching technologies to reduce bandwidth demand and improve user experience.

Although policy may ban or discourage a certain type of Internet use, in practice it can be difficult to completely enforce that policy purely by technical means. For example, an institution may have a policy of limiting the use of file sharing. However, determined users can tunnel file sharing over other protocols like HTTP, which is difficult or impossible for the institution to detect.

Trends in developing countries

As the number of Internet users in underdeveloped parts of Africa and Asia expands, there will also be a growing need to provide more local services. It will become more important for copies of large files (e.g. open-source software) to be stored on servers closer to users, which will enhance the speed and reliability of downloads. This technique, called "mirroring," is already widely used in the developed world, but there are no known public mirrors of popular software on the African continent.

Even today, 59% of African universities have limited or no bandwidth management, according to a report by ATICS (p.47). As small Local Area Networks (LANs) are created and extended, it is likely that more and more people will become de facto network administrators, despite having little or no training. If this training shortage problem is not addressed, the situation can only become worse.

Organisations with tighter budgets, such as universities, colleges, and research institutes, will continue to suffer with respect to the private sector in terms of the speed and reliability of their Internet connections. Unfortunately, these are the same institutions which cannot afford the best systems administrators, and where the public benefit that would arise from unfettered access to information is greatest.

As the knowledge of cheaper phone calls over the Internet spreads in developing countries, coupled with gradually increasing bandwidth and gradually spreading networks, users will start to demand faster and better Internet connections. This will erode the revenue of national monopoly telecom providers, who will seek greater legal protection of their monopolies. Hard battles will continue to be fought over industry deregulation in developing countries.

Newer bandwidth management software and network hardware, with better support for guaranteed network Quality of Service (QoS), will spread beyond the best equipped networks. Thus administrators will find themselves under pressure to implement these systems on their networks.

Conversely, shared bandwidth connections such as ADSL will continue to grow in popularity, at the expense of guaranteed bandwidth connections such as leased lines. While these seem cheaper, and often offer better performance on average, shared connections make it very difficult to manage bandwidth since the usable bandwidth is unknown and constantly varying. While Service Level Agreements (SLAs) can bind an ISP to provide a specified minimum level of performance, these agreements can come at a significant cost, particularly in areas that have little competition between providers.

New software

Aidworld and KENET are currently developing a simple open source toolkit which will provide affordable, reliable bandwidth management. While commercial solutions already exist, they are expensive and targeted at large organisations. The toolkit is designed for use in any institution regardless of size, bandwidth or staff experience.

BC Router, a project in development at Leuven University, is designed to provide fair bandwidth for all users on a network. It does this by providing an equitable share of bandwidth for each user at the packet level - and therefore across all protocols and all uses. With a per-user allocated bandwidth allowance, people who abuse the network will be the ones most affected since any increase in traffic will just consume their bandwidth share. This project is already live within the university, but at the time of writing is not yet ready for general release.

Other mini-distributions are beginning to evolve that integrate bandwidth management tools with a simple configuration interface. The development of tools such as IPCop (<http://www.ipcop.org/>), m0n0wall (<http://m0n0.ch/wall/>), and SmoothWall (<http://www.smoothwall.org/>) are bringing sophisticated traffic shaping and firewall tools into the hands of less experienced network administrators, and can be run on conventional PC hardware. In time, this should help

to make good bandwidth management techniques part of every standard Internet connection.

In closing

The ultimate vision of the Internet is a truly ubiquitous network where information flows freely to wherever humans can make use of it. It is likely that we will eventually build a network where there is sufficient bandwidth for all. But until this is achieved, we must continue to carefully manage network resources, ensuring that this limited resource is equitably accessible to everyone.

The technologies that allow us to effectively manage Internet resources are evolving as quickly as the Internet. New techniques and tools are being developed every day that help us to squeeze even more performance out of our overburdened network connections. Be sure to check in at our web site (<http://bwmo.net/>) for more resources and future updates to this work.