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# Investigating a Solution to the ResNet Bandwidth Problems at the University of Tennessee

Tracy Allen Cain
*University of Tennessee - Knoxville*

## UNIVERSITY HONORS PROGRAM

## SENIOR PROJECT – APPROVAL

Name: **Tracy Allen Cain**

College: **Arts & Sciences** Department: **Computer Science**

Faculty Mentor: **Dr. Steve Batsell**

PROJECT TITLE: **Investigating a Solution to the ResNet Bandwidth Problems at the University of Tennessee**

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed: Stephen Batsell, Faculty Mentor

Date: 2 April 2002

Comments (Optional):

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by

T. Allen Cain

Dr. Steve Batsell, Faculty Mentor

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## Abstract

Since the release of Napster in 1999, the University of Tennessee, like many other colleges and universities, has been experiencing increasing network congestion due to peer-to-peer (P2P) file sharing programs. This is especially apparent on UT's Residential Network Internet link. Even after an increase in dedicated bandwidth, the problems persist.

The Student Government Association has worked closely with the Office of Information Technology in seeking a solution to the problems, which frustrate students attempting to use the Internet for academic purposes. Past efforts, however, have not been as effective as hoped in alleviating the network congestion issues. A scalable, cost-efficient, and relatively simple solution is needed before congestion once again reaches unacceptable levels.

This paper surveys some of the current options in the areas of policy and technology, compares their benefits versus their costs and problems, and analyzes their applicability to the University of Tennessee's situation. Student Government and Administration involvement, commercial products, costs, and future plans are discussed. After investigation, it appears that a solution grounded in not only technology but policy is appropriate for UT. An enforceable "Good Net Citizen" policy combined with traffic policing technology is suggested as a solution.

# INVESTIGATING A SOLUTION TO THE RESNET BANDWIDTH PROBLEMS AT THE UNIVERSITY OF TENNESSEE

## BANDWIDTH PROBLEMS AT UT

Beginning with the advent of the Napster file-sharing program in 1999, the University of Tennessee Residential Network (ResNet) has experienced very high rates of traffic through its DS-3 link to the Internet. These issues have increased in severity with the release of other peer-to-peer (P2P) software such as Morpheus, Gnutella, and KaZaa, and the congestion the programs create does not appear to be subsiding. Since students are basically the only users of ResNet, the Student Government Association and the Office of Information Technology have worked closely to formulate a solution to the network problems; however, an effective, scalable, and cost-efficient remedy has not been agreed upon. This paper endeavors to bring together past work with a survey of some of the most common policy-based and technological solutions to P2P-based network congestion. After an analysis of the research, flow-rate limiting combined with a well-enforced "Good Net Citizen" policy are recommended as the proper course of action for the University of Tennessee.

## UT RESNET AND THE CAMPUS NETWORK

UT ResNet provides network connectivity to each of the thirteen residence halls on the Knoxville campus. This equates to approximately 5000 to 6000 individual users, depending on enrollment, number of students living in residence halls, and the number of those students with computers. Each student room is equipped with one to four 10 Mbps Ethernet connections which are linked to a switch with a 100 Mbps uplink to the backbone router in the residence hall. This router, in turn is connected to the campus backbone that operates at 1 Gbps. From the backbone, ResNet traffic is routed to a dedicated full-duplex 45 Mbps DS-3 level connection to the University's Internet service provider. Faculty, staff, and OIT laboratory computers are connected to the same campus backbone; however, traffic from these sources is routed through a separate, "academic" DS-3 connection. Additionally, UT is connected to the Internet2 research network, and traffic destined for Internet2 universities and organizations is routed through this link. While the "academic" Internet link experiences issues with P2P software similar to those encountered on ResNet, the problems can be mitigated through other methods such as regulation of software installed on University-owned computers.

## P2P PROGRAMS

The primary cause of the bandwidth problems is P2P file-sharing software. These programs allow an individual to connect to a network of other users and exchange music, video, and other types of files. This paper avoids the issue of copyright infringement, considering the problems only related to network bandwidth. The main issue with the programs is the functionality they provide in terms of uploading music to other users and the fast speeds at which colleges and universities are connected to the Internet. The outbound traffic on the ResNet DS-3 has often peaked at up to 99%, with the majority of the usage due to P2P programs. This congestion prevents other traffic such as World Wide Web and FTP from sending requests and data to servers and slows down users' response times.

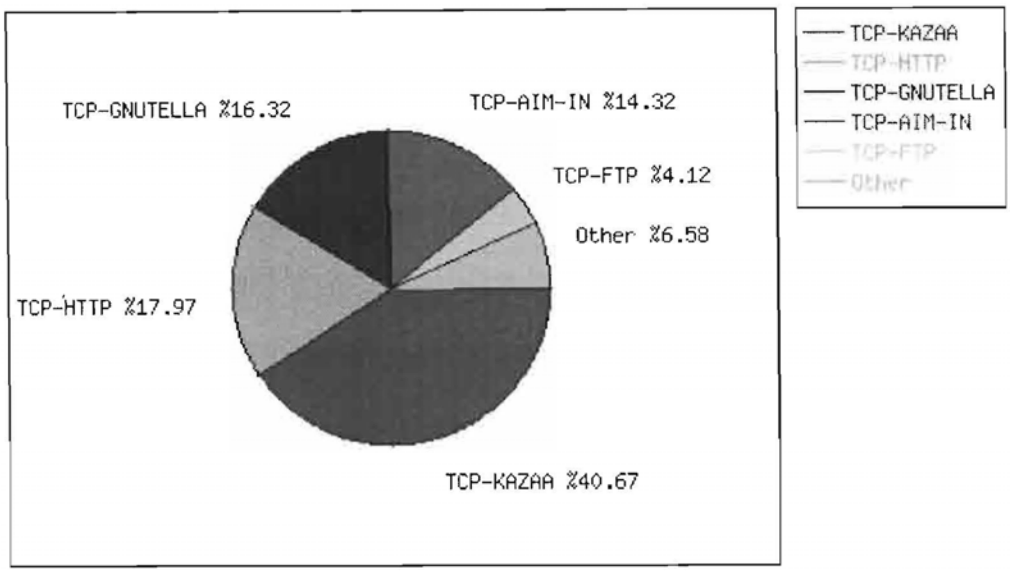


Figure 1. OIT NetFlow Graph for April 21, 2002 for ResNet DS-3

There are three basic types of P2P programs commonly in use: Napster, Gnutella, and KaZaa / FastTrack.

**Napster**

The first version of Napster was released in 1999, and it quickly became popular among college students. As a result of the popularity of retrieving "free" copies of music, network utilization at colleges and universities quickly jumped to extreme levels. The software is not a "true" peer-to-peer application, instead requiring a centralized server to act as an intermediary among users. When a user starts the Napster application, it logs on to one of several main servers and retrieves a list of other users who are connected and the songs that they are sharing. If the user finds a song that he likes, a request is sent to an individual who has a shared copy of that song, and a transfer between individual users is started. Napster is no longer a problem because of the fallout from lawsuits brought against the company by such groups as the Recording Industry Association of America and the band Metallica. Napster has been moving toward a pay service; however, users are not adopting this service because they can find what they want elsewhere

**Gnutella**

As Napster declined in popularity, alternative P2P programs were developed. One of the first is Gnutella, a true P2P application. There are several clients based on the Gnutella network such as BearShare and LimeWire but they all operate using the same basic methods and the same network. When a user starts a Gnutella client, the client broadcasts a message intended for other Gnutella clients notifying them of its presence, connection speed, and other statistics. In turn, the receiving client responds to other clients with its current list of known users. In this way, an intricate network of individuals is formed. There is no central Gnutella server; all requests are handled directly by the client software.

### KaZaa / FastTrack

KaZaa is the most popular file-sharing service today. It is based on technology from FastTrack, a Dutch company. Like Gnutella clients, it handles requests on a true P2P basis, but KaZaa and other programs based on FastTrack also include logon functions in order to push advertising to the client. In addition to the file-sharing aspect of the software, KaZaa also includes software from Brilliant Digital Entertainment that turns a client computer into a P2P content distribution node, often without a user's knowledge. This creates even more bandwidth issues and also introduces a security issue into the software.

## WHAT CAN BE DONE TO SOLVE THE PROBLEM?

There are many possible options that would help alleviate the ResNet bandwidth problems. These can be grouped into two main areas of focus: policy-based solutions and technological solutions. There are several options which cover both areas; they are presented in the sections which are most applicable.

### Policy-based Solutions

Policy-based solutions are those that can be implemented with few or no technical changes to the current configuration of the network. They include:

***Student Education Campaign.*** The Student Government Association attempted a campaign to inform users of the problems associated with P2P programs and how to configure the programs to disable sharing. However, students either did not care about the issue or did not wish to take the time to disable file sharing. In addition, there were those students who were knowingly sharing files and did not wish to disable the server software. Other institutions have had similar experiences with education campaigns.

***Enforcement of "Good Net Citizen" Policy.*** In essence, a "Good Net Citizen" policy is an extension of an Acceptable Use Policy (AUP) for access to and use of information technology resources. The UT AUP specifically states that, "No one shall interfere with the intended use of UTK IT resources. All users shall share computing resources (e.g., bandwidth) in an ethical and fair manner and not unduly interfere with use by other authorized users." The strict enforcement of this policy through proper channels should be an important aspect of any solution.

***"Fair Share" or Metering Policy.*** A metering policy is based upon what is determined to be a user's "fair share" of the available network resources. For instance, the University of Texas in Austin set a 3.5 gigabyte per week limit on data transfers on an individual network port. If a user exceeds this allowance, his port is shut off. The user may request an extra 500 megabytes for that week, but after this "bandwidth grant," the user receives no more data transfer allowance for that week. While this approach limits the amount of harm that an individual may cause, it is not the most student-friendly option. Additionally, there is the issue of who should decide what a "fair share" is and how much that amount should be. The metering policy also requires certain changes and more permanent staffing that would be prudent at the University of Tennessee, given the current budget situation.

***Network Access Charges***. Additional network access charges for users of ResNet are another policy option. This additional money could be used for more bandwidth or more staffing for greater monitoring. However, paying for a service that is currently "free" is never a popular solution. Additionally, there would be the issue of who collects the fees: either the Department of University Housing or the Office of Information Technology. Finally, with a current Technology Fee and the prospect of more tuition increases in the coming years, charging students additional fees would not be a good option to solve the ResNet problems

**Technological Solutions**

Technological solutions are implemented mostly within the network hardware or software. Some technological solutions include:

***Add More Capacity.*** The first technological option available to alleviate the ResNet bandwidth problems is to simply add more network capacity on the link to the Internet. This option, however, is not optimal for several reasons. First, adding more capacity costs money. Currently, the ResNet DS-3 costs several thousand dollars per month. Adding more capacity would involve buying new equipment and negotiating new contracts the UT's Internet service provider.

Additionally, the P2P program causing the problems are very opportunistic and take advantage of all available bandwidth. When the ResNet Internet link was separated from the "academic" Internet link, traffic quickly rose to near 100% utilization within a matter of days. Finally, this solution is not scalable. Simply adding more capacity is not feasible for UT in the long run because of the nature of bandwidth usage and inflexibility in capacity growth.

***Block Well-Known Ports.*** Another technical solution would be to block the well-known ports that the common P2P applications utilize at the DS-3 gateway. For instance, KaZaa / FastTrack is known to use TCP port 1214. This would eliminate traffic initially, but P2P programs are often written to seek out other ports to use if their common port is not available. Also, many programs allow the user to set a specific port, thus nullifying the effects of blocking the traffic. Bookkeeping and maintenance to combat the port changes would require detailed traffic analysis and administrator action, which are not economically feasible given UT's current funding state. Thus blocking ports would not be a long-term effective solution.

***Traffic Shaping***. Traffic shaping is a Quality of Service (QoS) mechanism that smoothes data flows across a specified device in a network (typically a router or switch). The basic premise of traffic shaping involves buffering network flows to eliminate bursts of data across the network. Currently, the University of Tennessee uses Cisco routers and switches, which implement a Cisco product called Generic Traffic Shaping (GTS). This implementation of traffic shaping eliminates data loss through queuing and buffering through a token-bucket mechanism, thus preserving the integrity of real-time applications such as streaming video and voice-over-IP. However, it requires more configuration work and is more involved than traffic policing. Thus, while traffic shaping appears promising, other options should be considered first.

***Traffic Policing***. UT's Cisco network equipment also allows traffic policing through a technology known as Committed Access Rate (CAR). Traffic policing differs from traffic shaping in that policing takes place on an entire data stream, be it for a single application or all of the data coming from one subnet or port. Policing also does not involve buffering. Cisco's CAR can be used for rate limiting based on several criteria such as application type, QoS parameters, or address characteristics. If a flow is encountered that exceeds the CAR access policy limits, packets are dropped until the flow conforms. While this may drop some minute amounts of data, the typical student can accommodate a few packets being dropped. In addition, the DS-3 link is well suited for the CAR technology.

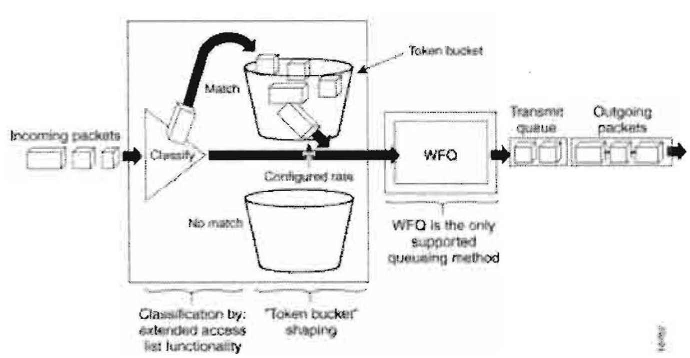

Figure 2. The Token Bucket Algorithm. From
<http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/12cgcr/qos_c/qcpart4/qcpolts.htm#xtocid241932>

CAR is implemented using a token-bucket filtering algorithm implemented in an uplink switch or a router on the edge of the network. A committed rate is configured for an interface or subnet and a set number of tokens of the given size are allocated for the specified traffic. Data that arrives and finds sufficient tokens is allowed to pass; while data that exceeds the token limit is either handled by a specified burst policy or is regulated down to an acceptable level.

## RECOMMENDATION

The University of Tennessee currently has a large installed base of Cisco equipment, and the network engineers are familiar with this hardware. Also, UT currently has an Acceptable Use Policy and a "Good Net Citizen" policy. Based upon research and work with the Student Government Association, it is recommended that traffic policing utilizing CAR and enforcement of the Acceptable Use Policy be used to alleviate the ResNet bandwidth problems.

Committed Access Rate technology could be implemented in such a manner as to provide for asynchronous data transfers to and from individual computers. This could be developed much like a Digital Subscriber Line connection provided by various Internet service providers. DSL provides a greater downstream capacity than upstream. Since upstream Internet congestion is the main problem on ResNet, a lower rate, for instance, 384 Kbps, could be provided, while maintaining the 10 Mbps downstream rate. Since the Acceptable Use Policy states that no users should interfere with the efficient operation of the network, CAR would simply be a technology-based implementation of the AUP. Finally, CAR is scalable, in that as network capacities or demands grown, policies can be changed or tweaked to meet the demands of specific users, applications, or other situations.

## LIMITATIONS

Unfortunately, research could not be performed on the live ResNet DS-3 due to the researcher's status as a student and lack of knowledge of actual implementation of Cisco protocols. Additionally, the ResNet Internet connection is essential for student use, and any interruption in service could prove to be detrimental to the researcher's well being. Finally, World Wide Web resources were used due to the inability to locate other types information applying specifically to the ResNet area of expertise. However, the online resources are chosen to represent a broad sampling of current experience in the area of ResNet bandwidth issues.

## FOR FURTHER RESEARCH

There are several other topics that could be investigated with relation to ResNet. The emerging field of IP QoS and Differentiated Services promises to provide a consistent methodology for providing specific service levels to users or consumers. Also, load sharing among the various Internet links that belong to UT is an interesting idea, if used in combination with QoS constraints. QoS would serve to prevent interruption of the University's vital missions of research, outreach, and education.

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