International Journal of Wireless Communications, Networking and Mobile Computing
2015; 2(2): 27-32
Published online September 10, 2015 (http://www.aascit.org/journal/wcnmc)

American Association for Science and Technology

Keywords
Packets,
Internet Traffic,
Bandwidth,
Protocol,
Intelligent Shaping

Received: March 30, 2015
Revised: April 20, 2015
Accepted: April 21, 2015

Network Congestion Analysis and Control Management

Okikiola F. M., Oladosu O. A., Adebayo A. A., Ogunjimi O. A., Akinade A. O.

Department of Computer Technology, Yaba College of Technology, Yaba, Lagos

Email address

sade.mercy@yahoo.com (Okikiola F. M.), kunledosu@gmail.com (Oladosu O. A.), adeniranadebayo5585@yahoo.com (Adebayo A. A.), olaogunjimi@gmail.com (Ogunjimi O. A.), akinadejemima@yahoo.com (Akinade A. O.)

Citation

Okikiola F. M., Oladosu O. A., Adebayo A. A., Ogunjimi O. A., Akinade A. O.. Network Congestion Analysis and Control Management. *International Journal of Wireless Communications, Networking and Mobile Computing*. Vol. 2, No. 2, 2015, pp. 278-32.

Abstract

Internet Traffic Engineering is defined as that aspect of Internet network engineering dealing with the issue of performance evaluation and optimization of operational IP networks. Traffic Engineering encompasses the application of technology and scientific principles to the measurement, characterization, modeling, and control of Internet traffic. Enhancing the performance of an operational network, at both traffic and resource levels, are major objectives of Internet engineering. Traffic oriented performance include packet transfer delay, packet delay variation, packet loss, and throughput. Packet transfer delay is a concept in packet switching technology. The sum of store-and-forward delay that a packet experiences in each router gives the transfer or queuing delay of that packet across the network. Packet transfer delay is influenced by the level of network congestion and the number of routers along the way of transmission. Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. Packet loss is distinguished as one of the three main error types encountered in digital communications; the other two being bit error and spurious packets caused due to noise. The fraction of lost packets increases as the traffic intensity increases. Therefore, performance at a node is often measured not only in terms of delay, but also in terms of the probability of packet loss.

1. Introduction

Internet traffic is the flow of data across the Internet. Because of the distributed nature of the Internet, there is no single point of measurement for total Internet traffic. Internet traffic data from public peering points can give an indication of Internet volume and growth, but these figures exclude traffic that remains within a single service provider's network as well as traffic that crosses private peering points. Fixed Internet Traffic refers perhaps to traffic from residential and commercial subscribers to ISPs, cable companies, and other service providers. Mobile Internet Traffic refers perhaps to backhaul traffic from cellphone towers and providers (Williamson, 2001).

In computer networking, network traffic control is the process of managing, prioritizing, controlling or reducing the network traffic, particularly Internet bandwidth, e.g. by the network scheduler. It is used by network administrators, to reduce congestion, latency and packet loss. This is part of bandwidth management. In order to use these tools effectively, it is necessary to measure the network traffic to determine the causes of network congestion and attack those problems specifically. Traffic shaping (also known as "packet shaping") is a computer network traffic management technique which delays

some or all datagrams to bring them into compliance with a desired traffic profile(IEEE INFOCOM 2001). Traffic shaping is a form of rate limiting. Traffic shaping is used to optimize or guarantee performance, improve latency, and/or increase usable bandwidth for some kinds of packets by delaying other kinds. If a link becomes saturated to the point where there is a significant level of contention (either upstream or downstream) latency can rise substantially. Traffic shaping can be used to prevent this from occurring and keep latency in check. Traffic shaping provides a means to control the volume of traffic being sent into a network in a specified period (bandwidth throttling), or the maximum rate at which the traffic is sent (rate limiting), or more complex criteria such as GCRA. This control can be accomplished in many ways and for many reasons; however traffic shaping is always achieved by delaying packets (Helzer, 2013).

Traffic shaping is commonly applied at the network edges to control traffic entering the network, but can also be applied by the traffic source (for example, computer or network card) or by an element in the network. Traffic policing is the distinct but related practice of packet dropping and packet marking. The technique of selecting or categorizing traffic into different types or classes is traffic classification. Traffic shaping is sometimes applied by traffic sources to ensure the traffic they send complies with a contract which may be enforced in the network by a policer. It is widely used for network traffic engineering, and appears in domestic ISPs' networks as one of several Internet Traffic Management Practices (Helzer, 2013).

2. Internet Traffic Management

Traffic shaping is a popular idea among ISPs because it allows them to charge customers more for popular services, such as Facebook or Netflix. In this way, the Internet can be packaged into tiered categories, the same way that Cable television is packaged into basic cable, sports packages, and premium packages. Although the U.S. District Court has ruled this to be a violation of the basic principles of the Internet, ISPs see it as a way to increase profits without upgrading their networks. To ISPs, mere protocol identification (classification) gives the intangible yet significant benefit of seeing what internet traffic is flowing through the network. From this they can see which subscribers are doing what on their network and can target services to the subscriber base they have attracted. However as time progresses, more and more protocols are using tunneling and encryption to defeat these methods. Also, many protocols are very difficult or impossible to detect. In such cases, per-client shaping is more effective (Helzer, Xu(2013).Cisco predicts that the number of network-connected devices will be more than 15 billion, twice the world's population, by 2015. In the fifth annual Cisco® Visual Networking Index (VNI) Forecast (2010-2015) released, the company also said the total amount of global Internet traffic will quadruple by 2015 and reach 966 exabytes per year. The projected increase of Internet traffic between 2014 and 2015 alone is 200 exabytes, which is greater than the total amount of Internet Protocol traffic generated globally in 2010. On the verge of reaching 1 zettabyte, which is equal to a sextillion bytes, or a trillion gigabytes by 2015, global IP traffic growth is driven by four primary factors, according to Cisco. The proliferation of tablets, mobile phones, connected appliances and other smart machines is driving up the demand for connectivity. By 2015, there will be nearly 15 billion network connections via devices -- including machine-to-machine -- and more than two connections for each person on earth. More Internet users: By 2015, there will be nearly 3 billion Internet users -- more than 40 percent of the world's projected population. The average fixed broadband speed is expected to increase four-fold, from 7 megabits per second in 2010 to 28 Mbps in 2015. The average broadband speed has already doubled within the past year from 3.5 Mbps to 7 Mbps. More video: By 2015, 1 million video minutes --the equivalent of 674 days --will traverse the Internet every second. The annual Cisco VNI Forecast was developed to estimate global Internet Protocol traffic growth and trends. Widely used by service providers, regulators, and industry influencers alike, the Cisco VNI Forecast is based on in-depth analysis and modeling of traffic, usage and device data from independent analyst forecasts. Cisco validates its forecast, inputs and methodology with actual traffic data provided voluntarily by global service providers and consumers alike (Cisco, 2013). By establishing policies based on the IP or IP grouping of a client, ISPs ensure that end users cannot defeat shaping by disguising protocols or encrypting their traffic. In addition, intelligent shaping schemes can guarantee a particular Quality of Service (often measured in jitter, packet loss, and latency) for an application or a user while still allowing other traffic to use all remaining bandwidth. This allows ISPs to offer Differentiated services and to upsell existing services to subscribers (such as offering minimum-latency computer gaming for an additional fee on top of basic internet). More importantly, shaping allows ISPs to tier their services using software, reducing their costs and increasing the menu of products they can offer. For Wireless ISP's, particularly those who use Wifi-based protocols, Congestive collapse is a serious problem. Due to the unfortunate nature of Wifi when several stations are all trying to access a single access point at once, once the load is past roughly 95% channel load, the throughput starts to drop dramatically. Whilst the channel stays at the same usage (roughly 99%), the throughput just gets slower and slower due to the number of retries. TCP performance may be greatly impacted by the long delay over the wireless link caused by the congestion at the access point. A long delay can cause expiration of the TCP RTO timer at the sender's side and then force TCP into slow-start. On the other hand, if the long delay is experienced on the ACK path, it could cause the so-called "ACK compression", which will disturb the synchronization between the TCP sender and the TCP receiver. Multiple compressed ACKs if passing through

the wireless access point all together can clock-out the same amount of large packets from the TCP sender and all of them may arrive at the wireless bottleneck in a short time and further worsen the congestion there. Therefore traffic shaping should be seriously considered on a WISP in order to avoid these possible performance impacts(Helzer, Xu(2013).

Traffic Shaping and also prioritization are becoming more and more common in the corporate market. Most companies with remote offices are now connected via a Wide area network (WAN). Applications tend to become centrally hosted at the head office and remote offices are expected to pull data from central databases and server farms. As applications become more hungry in terms of bandwidth and prices of dedicated circuits being relatively high in most areas of the world, instead of increasing the size of their WAN circuits, companies feel the need to properly manage their circuits to make sure business-oriented traffic gets priority over best-effort traffic. Traffic shaping is thus a good means for companies to avoid purchasing additional bandwidth while properly managing these resources.

Table 1. *Analysis of Packets in a Packet-Switch Network.*

Ports	Bytes Sent	Bytes Received	Total Bytes	Packet Sent	Packet Received	Total Packets	Absolute Byte Loss	Absolute Packet Loss
http (80)	57150	11844	68994	87	108	195	45306	21
netbios-dgm (138)	11259	11259	22518	48	48	96	0	0
netbios-ns (137)	10326	10326	20652	99	99	198	0	0
netbios-ssn (139)	4879	5589	10468	42	42	84	710	0
ftp (21)	3993	4707	8700	45	75	120	714	30
ftp-data (20)	1818	1068	2886	30	18	48	750	12
9998	480	480	960	6	6	12	0	0

Alternatives to traffic shaping in this regards are application acceleration and WAN optimization and compression, which are fundamentally different from traffic shaping. Traffic shaping defines bandwidth rules (or partitions as some vendors call them) whereas application acceleration using multiple techniques like a TCP Performance Enhancing Proxy. WAN optimization and compression (WOC) on the other hand would use compression and differential algorithms and techniques to compress data streams or send only differences in file updates. The latter is quite effective for chatty protocols like CIFS (Morgan, 2007).

Traffic shaping is of interest especially to Internet Service Providers (ISPs). Their high-cost, high-traffic networks are their major assets, and as such, are the focus of all their attentions. They sometimes use traffic shaping to optimize the use of their network, sometimes by intelligently shaping traffic according to importance, other times by discouraging uses of applications by harsh means.[9] There are those who believe it is not the ISP's place to decide what is "important"; in such cases per-client traffic shaping is more effective without creating potential controversies about what traffic is being controlled. Traffic shaping is a specific technique and one of several which combined constitute Bandwidth management. Current common usage, particularly in discussion of domestic Internet service provision, frequently confuses traffic shaping with traffic management and traffic policing, with classification policies and in general with any measure deliberately taken by an ISP which is detrimental to some user's IP traffic performance (Sandvine, 2002).

Internet traffic management, also known as application traffic management, refers to tools that monitor the flow of Web application traffic over a network. These tools route traffic among multiple devices within a network, limiting delays and freeing bandwidth. The F5 BIG-IP product family monitors network traffic for problems that may compromise critical data and hinder application performance. The BIG-IP product family provides complete network transparency, enabling automated application security and comprehensive traffic management (f5, 2013).

The Internet Traffic Archive is a moderated repository to support widespread access to traces of Internet network traffic, sponsored by ACM SIGCOMM. The traces can be used to study network dynamics, usage characteristics, and growth patterns, as well as providing the grist for trace-driven simulations. The archive is also open to programs for reducing raw trace data to more manageable forms, for generating synthetic traces, and for analyzing traces. Traces contributed to the archive have no restrictions as to what use may be made of them (except for traffic analysis as noted below). Traces may however have restrictions on redistribution. Software contributed to the archive is in general copyrighted. Traces contributed to the archive often will have been filtered to some degree to preserve the privacy of the network users whose traffic was traced, and to address network security concerns. The *Privacy* information associated with the trace details these changes. *Archive users agree to not perform traffic analysis aimed at circumventing the degree of privacy present in a trace (ita., 2013).*

When given a situation where the amount of content due to be pushed through a connection is growing at a rate greater than it is possible to push through that connection, also known as a bottleneck, then there is no other solution than to drop packets. The TCP protocol is designed with a slow-start connection strategy so that excessive packet loss will cause the sender to throttle back and stop flooding the bottleneck point with data (using perceived packet loss as feedback to discover congestion). The data packets will be transmitted over a longer duration. There are many methods used for determining which

packets to drop. Most basic networking equipment will use FIFO queuing for packets waiting to go through the bottleneck and they will drop the packet if the queue is full at the time the packet is received. This type of packet dropping is called tail drop. However, dropping packets when the queue is full is a poor solution for any connection that requires real-time throughput. In cases where quality of service is rate limiting a connection, packets may be intentionally dropped in order to slow down specific services to ensure available bandwidth for other services marked with higher importance (like those used in the leaky bucket algorithm). For this reason, packet loss is not necessarily an indication of poor connection reliability or a bottleneck. Packet loss is closely associated with quality of service considerations, and is related to the enlarge unit of measure. As a rule of thumb derived from day-to-day practical experience, in general with TCP/IP protocols a packet loss below 0.1% (1 lost packet in every 1000 packets) can be tolerated; anything higher will have more or less impact (depending on circumstances) and needs to be addressed(Kurose, 2010).

An important objective of Internet traffic engineering is to facilitate reliable network operations. Reliable operations can be facilitated by providing mechanisms that network integrity and by embracing policies emphasizing survivability. This results in a minimization of the network to service outages arising from errors, faults, failures occurring within the infrastructure. The Internet exists in order to transfer information from nodes to destination nodes. Accordingly, one of the most crucial functions performed by the Internet is the routing of traffic ingress nodes to egress nodes. Ultimately, it is the performance of the network as seen by end of network services that is truly paramount. This crucial function should be considered throughout the development of engineering mechanisms and policies. The characteristics visible end users are the emergent properties of the network, which are characteristics of the network when viewed as a whole. A goal of the service provider, therefore, is to enhance the properties of the network while taking economic considerations account. The importance of the above observation regarding the properties of networks is that special care must be taken choosing network performance measures to optimize. Optimizing wrong measures may achieve certain local objectives (Abdel-Hameed, 2005).

Teletraffic engineers use their knowledge of statistics including queuing theory, the nature of traffic, their practical models, their measurements and simulations to make predictions and to plan telecommunication networks such as a telephone network or the Internet. These tools and knowledge help provide reliable service at lower cost.

3. Research Methodology

The field was created by the work of A. K. Erlang for circuit-switched networks but is applicable to packet-switched networks, as they both exhibit Markovian properties, and hence can be modeled by e.g. a Poisson arrival process. The crucial observation in traffic engineering is that in large systems the law of large numbers can be used to make the aggregate properties of a system over a long period of time much more predictable than the behaviour of individual parts of the system (Jones, 2013).

Net Balancer is an internet traffic control and monitoring tool designed for Microsoft Windows XP, 2003, Vista, 7, 8 with native x64 support.

With Net Balancer you can:

i. Set for any process a download and/or upload network priority or limit
ii. Manage priorities and limits for each network adapter separately
iii. Define detailed network traffic rules
iv. Group local network computers and balance their traffic synchronised
v. Set global traffic limits
vi. Show network traffic in system tray (Seriousbit, 2013)

4. Analysis, Results and Interpretation

The assumption that statistical multiplexing can be used to improve the link utilization is that the users do not reach their peak rate values simultaneously, but since the traffic demands are stochastic and cannot be predicted, congestion is unavoidable. Whenever the total input rate is greater than the output link capacity, congestion occurs. When the network becomes congested, the queue lengths may become very large in a short time, resulting in buffer overflows and cell loss. Congestion control is therefore necessary to ensure that users get the negotiated Quality of Service (QoS).

In packet-switched networks, packets move in and out of the buffers and queues of switching devices as they traverse the network. In fact, a packet-switched network is often referred to as a "network of queues." A characteristic of packet-switched networks is that packets may arrive in bursts from one or more sources. Buffers help routers absorb bursts until they can catch up. If traffic is excessive, buffers fill up and new incoming packets are dropped. Increasing the size of the buffers is not a solution, because excessive buffer size can lead to excessive delay.

4.1. Graphical Illustration

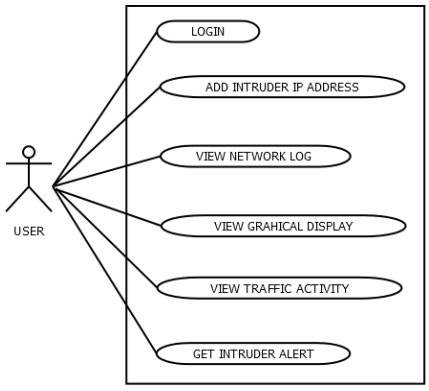

Fig. 1. *Use case Diagram.*

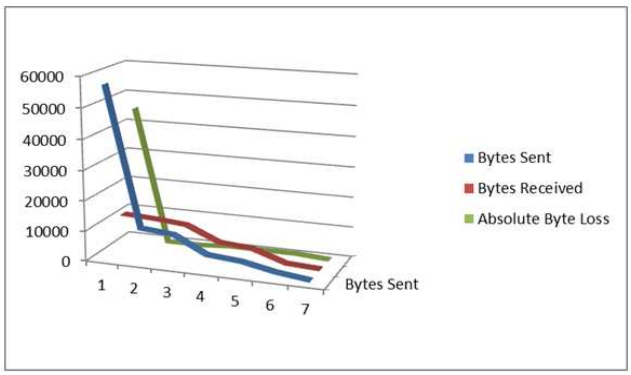

Fig. 2. *Number of Bytes Sent, Received and Absolute loss.*

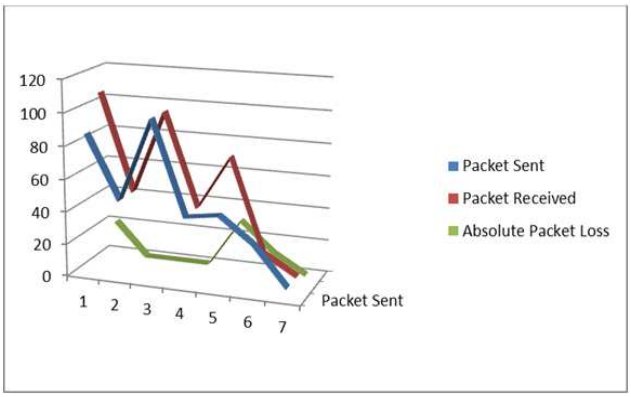

Fig. 3. *Number of Packet Sent, Received and Absolute loss.*

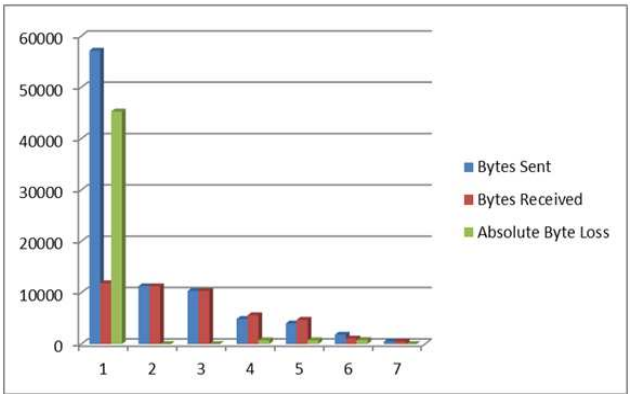

Fig. 4. *Multiple Bar Chart Illustration of Bytes Sent, Received and Absolute loss.*

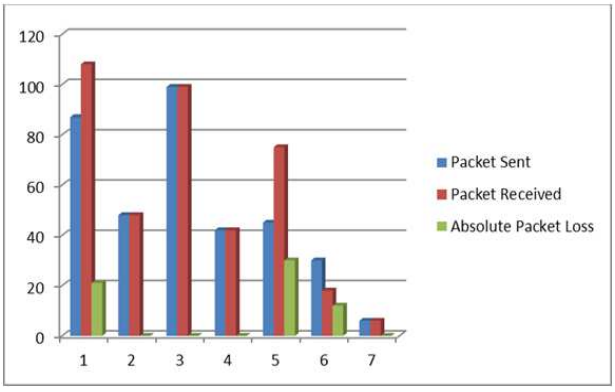

Fig. 5. *Multiple Bar Chart Illustration of Packet Sent, Received and Absolute loss.*

4.2. Interpretation

The result above shows that packet loss is experienced with particular protocol with respect to the port. Some of the port even had additional packet gain compared to the packet sent while in the others exactly the same amount of packet sent was received. Therefore, it directly shows that the exist a relationship between packet sent, packet received and packet loss which means that routing may account for the loss.

5. Summary and Conclusion

As times are changing so is the technology as well. Technology has been growing at a rapid rate to accommodate the current needs and the desires of the people. Unarguably, one of the greatest technologies of the modern era is the internet. It has become a phenomenon and an addiction to have one internet user amongst every five persons in the world today. Internet usage has now become a part of our daily life and without it we would be excluding ourselves from the world of technology advancement.

Recommendation

We can take this work further by making use of a more advance means of measuring the packet received and sent more accurately and propose a better way of improving the network to reduce and perhaps eliminate packet loss through transit.

References

[1] Williamson, Carey (2001). "Internet Traffic Measurement". IEEE Internet Computing 5 (6): 70–74. doi: 10.1109/4236.968834.

[2] IEEE INFOCOM 2001. Arsenic: a user-accessible gigabit Ethernet interface Pratt, I., Fraser, K., Computer Laboratory, Cambridge University; Twentieth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings 2001 Volume 1, pages: 67-76 vol.1. Describes a gigabit Ethernet NIC with transmit traffic shaping.

[3] Helzer, Xu(2013). Congestion Control for Multimedia Streaming with Self-Limiting Sources Josh Helzer, Lisong Xu

[4] Engelhardt, Sebastian (2008). "The Economic Properties of Software". Jena Economic Research Papers 2 (2008–045.).

[5] Kaminsky, Dan (1999). "Why Open Source Is The Optimum Economic Paradigm for Software". http://newsroom.cisco.com/press-release-content;jsessionid=9F2A5677FAC60C600EFC7966A7A89550?type=webcontent&articleId=324003

[6] Global Internet Traffic Projected to Quadruple by 2015

[7] "Deploying IP and MPLS QoS for Multiservice Networks: Theory and Practice" by John Evans, Clarence Filsfils (Morgan Kaufmann, 2007, ISBN 0-12-370549-5)

[8] "Peer-to-Peer File Sharing: The Impact of File Sharing on Service Provider Networks", Sandvine Incorporated, copyright 2002

[9] http://ita.ee.lbl.gov/: 2013

[10] Internet Traffic Management

[11] https://www.f5.com/glossary/internet-traffic-management/. 2013 F5

[12] Networks

[13] "The Open Market Internet Index". Treese.org. 1995-11-11. Retrieved 2013-06-15

[14] Robert H'obbes' Zakon. "Hobbes' Internet Timeline v10.1". Retrieved November 14, 2011. Also published as Robert H. Zakon.

[15] "Roads and Crossroads of Internet History" by Gregory Gromov. 1995.

[16] Hafner, Katie (1998). Where Wizards Stay Up Late: The Origins Of The Internet. Simon & Schuster. ISBN 0-684-83267-4.

[17] What is the role of teletraffic engineering in broadband networks? by Jones Kalunga cnx.org. 2013.

[18] Abdel-Hameed Nawar, "E-Commerce" Lecture Notes, Cairo University, Faculty of Economics and Political Science, Egypt, 2005.

[19] Kurose, J. F. & Ross, K. W. (2010). Computer Networking: A Top-Down Approach. New York: Addison-Wesley. P 30.

[20] NetBalancer - Traffic Control and Monitoring Tool:2013.

[21] http://seriousb Heeks, Richard (2008). "Meet Marty Cooper – the inventor of the mobile phone". BBC 41 (6): 26–33. doi:10.1109/MC.2008.192.

[22] "Gartner Says Worldwide Mobile Connections Will Reach 5.6 Billion in 2011 as Mobile Data Services Revenue Totals $314.7 Billion" (PDF). Gartner. 2010-07-09

[23] "Tech Talk: Where'd it Come From, Anyway?". PC World.