NETWORK TRAFFIC MODELING AND PLANNING
Performance Verification of Cable Networks

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Abstract

The dramatic growth in the volume of traffic over cable modems has increased the demand for traffic modeling and planning mechanisms for verifying cable network performance via traffic generators and analysis platforms. Packet generators of today offer highly sophisticated utilities to generate custom traffic mixes for Layer 2 and Layer 3 devices in an effort to simulate real-world Internet traffic patterns. In addition, such analysis systems assist cable network engineers in developing and deploying cable systems in the networks by measuring their performance and gathering metrics such as throughput, packet loss, and latency.

Within the past few years, Cable service operators have begun to integrate data services into their existing cable infrastructure. This is to fulfill the customer's desire for high-speed Internet access at a reasonable price. Also, this added service creates additional revenue for the MSO.

As the result of data services over cable, three major entities have emerged. They are the Small Office/ Home Office, Voice over Cable and Digital Video.

The Small Office / Home Office (SOHO) has benefited the most as a result of Data over Cable. Many companies have created network devices for the SOHO market.

Digital Cable, another result of Data over Cable improves the viewing quality of Television. Broadcasting downstream is a thing of the past. Multicasting provides an efficient way of delivering quality video to the subscriber.

Finally, voice over cable is the future of Data over cable, also known as PacketCable. Using this technology, a cable subscriber is able to make voice calls from a cable modem to anyone in the world.

Cable and DOCSIS

As Cable Modems are in its adolescent stages, CableLabs is conducting conformance tests by certifying Cable Modems and qualifying Cable Modem Termination Systems by verifying the basic functionality of the devices.

For the MSO, since there are so many Cable modems and CMTS's out there, they need to verify performance at the device level as well as the system level. It's up to the MSO to evaluate the performance of each cable device to find out which of the devices meets their requirements. It is also a requirement of the MSO to find out how these devices behave in a system environment. A typical cable company handles around 5000 to 30,000 subscribers.

Testing Requirements of Cable Device and Systems

As the development of cable networking devices gets more complex, performance analyzers must meet the conformance requirements of these manufacturers. In addition, as the MSO's implement the devices into their infrastructure, Performance Analyzers must meet the needs of this group as well. The Performance analyzer must take a role in assisting the MSO to provide as much information as possible on the following:

* Test the performance of the Cable Networking Device.

* Test the performance and identify any interoperability issues of any of the Cable devices that participates in the Cable System.

* Simulate the possible real world scenarios of the Cable system and assist in prestaging the system before deployment.

* Monitor and provide valuable information of the Cable network

* Identify any major problems after the system has been deployed.

Device Testing

In testing the performance of Cable Networking Devices, the following performance metrics of Throughput, Packet Loss and Latency should be used.

The device that consistently performs well in all of the three above categories should be considered. Device testing is very tricky because the performance of a Cable Modem is dependent upon the CMTS and vice versa. Therefore, the performance analysis of all combinations of different CMTS's and Cable Modems should be considered.

System Testing

Testing a typical system involves a CMTS with many modems. Questions arise when testing these systems.

For example:

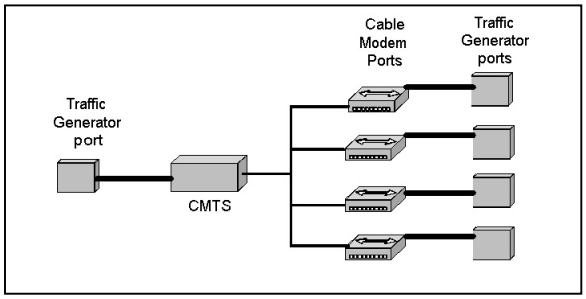
What is the maximum number of cable modems that meets the performance requirement of the CMTS?

What is the total aggregate throughput of a Cable System?

Is the system able to handle the basic requirements of the MSO like Throughput, Packet Loss, and Latency?

The Customer Premises Equipment (CPE) is another variable introduced into the system. The testing device must be able to simulate 1 or more CPE's per modem and on the CMTS side.

In the diagram below, the Traffic Generator/ Performance Analyzer is able to represent 1 or more CPE's on the same physical port.



The system that performs well to these questions should be considered.

Simulation of a Cable Network

Before deployment of a Cable Network or any Network for that matter, the equipment and personnel involved, must be prepared to identify any major flaws, improvements made to the system and expansion. A testing device must be able to simulate these scenarios in order to reduce downtime. In addition, it must provide information to the network administrator in order to make any improvements to that network. And finally, increase productivity of the network. The testing device should provide a solution to the following simulations:

* Quality of Service (QoS)
* Multicast

* Voice over IP
* Traffic shaping and modeling

Network Monitoring

To provide added value, the Test equipment should not only be used as evaluating Cable devices and systems, but also be included in the "nervous system" of the Cable Network. It should be able to warn the administrator of any security and fault issues in the network. Also, it should be able to provide performance analysis values of the whole network.

The performance analyzer should be able to filter packets that are meaningful as well as warn the administrator of the occurrence of an event. Examples include SYN attacks, severe errors, or link failure.

Traffic Modeling

Of all the testing devices and systems are being utilized today, most cable companies are most interested in the topic of traffic shaping and modeling. Traffic generators / performance analyzers today are able to simulate traffic based on a real cable network. To simulate the types of Internet traffic, one must find out what types of traffic is being passed through the network. Some types of traffic include the following:

* DHCP traffic-- as Cable Modems go through their registration process, they communicate via DHCP to the DHCP and TFTP servers to get their configuration files and IP addresses. CPE's also use the DHCP protocol to get IP addresses.

* Web traffic-- as users make HTTP requests to different web servers throughout the Internet. Web traffic is based on TCP sessions.

* Domain Name Service (DNS)-- is used to resolve a name with IP addresses. As more and more users access web pages, the web addresses are resolved by the DNS sever.

* Email traffic-- Most people have joined the bandwagon and communicate via e-mail in today's demand for high-speed communication. Different types of mail protocols generated are POP, SMTP, and IMAP to name a few.

* Real-time Transport Protocol (RTP)-- As digital cable and voice are integrated into the cable network, the information will be encapsulated into this protocol.

* File Transfer Protocol (FTP) -- Subscribers will definitely download or upload files between each other. Examples include download of technical documents, video and music files to name a few.

Once the matter has been researched, to measure the performance of the aggregate network, different types of proportions of traffic need to be generated in order to accurately simulate a typical cable network. In other words, the MSO needs to figure out the percentage of the specific types of traffic that must be generated.

The performance analyzer is used to generate custom traffic that can closely mimic real-world traffic, where the users send and receive IP traffic from their web pages. To simulate these web pages, the device needs to generate TCP, UDP, and HTTP traffic. The important characteristics of such traffic generation are:

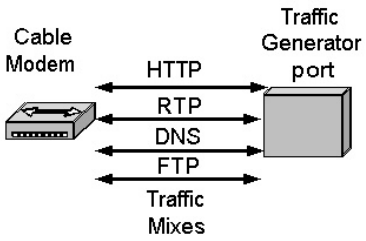
* Variable packet sizes
* Variable allocated bandwidth

* Priority (IP Type of Service)
* Bursty and fixed traffic

The testing procedures that simulate such characteristics can be complicated in nature.

Variable packet sizes are necessary because different types of traffic require different packet sizes. For example, TCP connections require small packets since the information exchanged is done by the TCP header and the payload is not necessary.

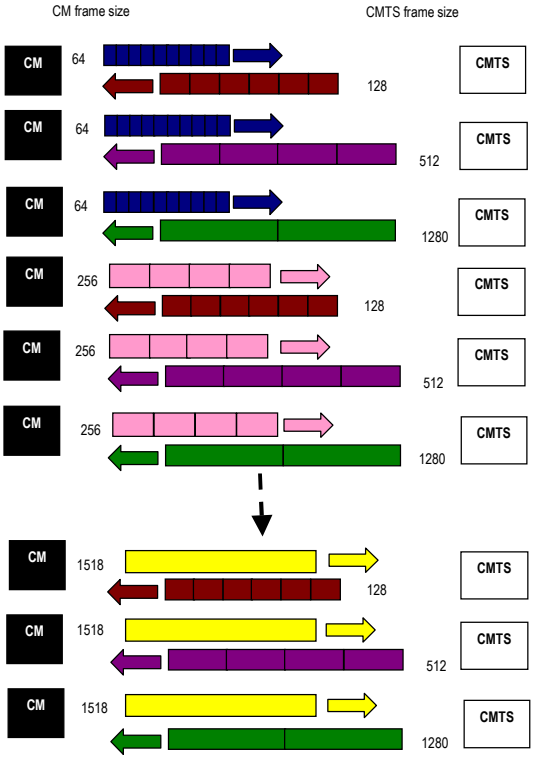
Voice packets require small size packets to maintain low latency and jitter. UDP traffic requires large packets because of the need to transfer as much information possible with less overhead. DHCP packets require medium-sized packets since the nature of transferring all the DHCP options.



Variable allocated bandwidth is taken into consideration when the ratio of traffic is different. The ratio of traffic also changes over time.

It is also necessary to generate bursty and fixed traffic. For example with voice packets, a fixed constant rate is needed to maintain constant latency and jitter. If the voice traffic is not constant, the voice quality decreases. Also, since multiple users randomly send and receive traffic, bursty types of traffic can closely simulate this situation.

In order to simulate real-world traffic, the device must generate randomized types of traffic. So variables will be randomized, the packet size, the type of traffic represent both the IP type (TCP/UDP) and their port numbers that represent HTTP, DNS, FTP etc.



In a Bidirectional test, frame sizes and the type of packets do not have to be the same.

Frame Size	Protocol	Precedence	% Bandwidth
80	TCP	3	20
64	RTP	1	10
570	DHCP	5	30
128	FTP	4	20
1518	UDP	8	20

Quality of Service

Quality of Service (QoS) is implemented in DOCSIS 1.1. With QoS in the cable modem world there are 2 terms associated with it. They are Service Flows and Classifiers. Different types of bandwidths are set on each Service flow to set priorities on

which types of packets are sent first. Each Service flow is based on one or more classifiers. The classifiers are based on different byte values at different offsets of the packet. Examples of classifiers are TCP/UDP ports, IP addresses, MAC addresses, and TOS Bits.

The analyzer used must be able to generate and analyze the traffic that matches these classifiers.

Conclusion

In conclusion, this article has discussed a variety of requirements necessary for a typical performance analyzer. The performance analyzer must be able to prepare and improve the quality of the Cable network in evaluating the network devices, simulate the environment in pre-deployment and assist in gathering performance metrics, as well as warn the administrator of any issues in post deployment