WHY SHOULD YOU CARE ABOUT DOCSIS? VOIP IS WHY!

The $45 billion yearly Cable Television (CATV) industry is positioned to directly compete with the $200 billion yearly Telephony industry. This is possible by building on the existing DOCSIS network. The enabling technology is Voice-over-Internet Protocol (VoIP) a number of call provisioning elements, Media Terminal Adapters (MTAs), and a DOCSIS™ network. The end result, increased revenue for the Cable Operator.

This paper will investigate the building block of VoIP – the DOCSIS network. In order to obtain the revenue generating opportunities of VoIP, it is essential to understand and troubleshoot a DOCSIS, (Data-Over-Cable Service Interface Specification) network. If all of the elements of the DOCSIS network are working properly, from RF to IP, then VoIP should be elementary, however if there are any RF impairments, DOCSIS protocol impairments, or IP data routing anomalies, then VoIP deployments can be disastrous. Understanding and identifying these impairments will require new technologies and understanding new concepts.

DOCSIS WORKING MODEL

Developed by CableLabs, DOCSIS is the specification which provides a standard for bridging Ethernet data over the HFC network. The DOCSIS specification defines the method by which DOCSIS-based devices operate on the RF plant. Fundamentally, there are three layers of communication which must be understood in order to analyze a DOCSIS network.

This model is best illustrated in figure 1. The base of the pyramid represents the physical layer of DOCSIS. This is where data is modulated and up-converted to an RF carrier for transport across the HFC plant. The middle of the pyramid is the DOCSIS Media Access Control (MAC) layer. This represents the inter-communications between DOCSIS-based devices that enable cable modems (CMs) and MTAs to communicate with the Cable Modem Termination System (CMTS). Finally, the top of the pyramid represents the layer at which Internet Protocol (IP) data is transported. This layer is used both by subscribers for data access and by CMs and MTAs during registration (explained later).

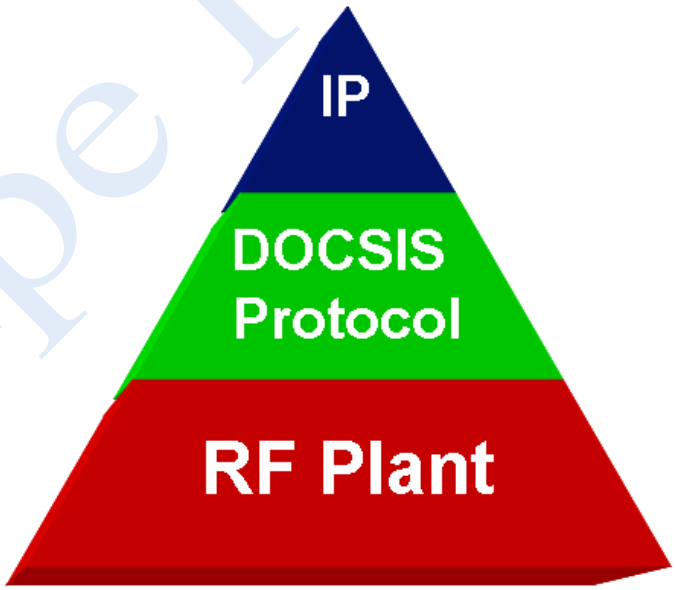

Figure 1. DOCSIS Working Model

TROUBLESHOOTING DOCSIS

In assessing and improving DOCSIS network reliability, it is critical that all three layers of the DOCSIS working model are analyzed. Impairments that occur in the RF plant may appear to be DOCSIS or IP related problems, similarly problems in the DOCSIS MAC or IP protocols may appear as RF impairments. This creates “finger pointing”, which results

in loss of time and money expenditures by attempting to resolve a problem which does not exist.

In order to solve this problem, we will first describe the origin of many common DOCSIS network problems. This is best done following the bottom up DOCSIS pyramid. Only after the problem has been defined can problem resolution begin.

RF PLANT IMPAIRMENTS

The majority of DOCSIS network problems occur at the physical or RF plant level. This is due to the fact that the RF network, particularly in the upstream, is inherently rich with mechanisms that will prevent or impair DOCSIS communications. Some very common and well known RF impairments are:

- Linear Impairments such as:
    - Micro-reflections
    - Amplitude & Group Delay
- Non-linear Impairments such as:
    - Common Path Distortion (CPD)
    - Return Laser Clipping
- Transient Impairments such as:
    - Ingress & Impulse Noise

Individually, these impairments may impact DOCSIS reliability and can be difficult to identify using conventional test equipment. For example CNR and SNR do not identify all RF impairments however MER does reflect all RF impairments. Collectively, these impairments create an environment that is nearly impossible to identify the source of network failures.

Analyzing individual cable modem performance requires new test equipment called **DOCSIS Protocol Analyzers**. These analyzers demodulate individual cable modem transmissions and provide both quantitative measurement of the signal's quality and information designating the source of the transmission. This is critical in DOCSIS networks because there are hundreds of individual cable modems simultaneously transmitting data. A DOCSIS protocol analyzer can filter on a single cable modem and provide signal quality measurements as shown in figure 2.

AVOIDING COSTLY AND POINTLESS TRUCK ROLLS

Equipped with this analyzer, a cable technician can see signal performance of a single cable modem experiencing performance issues and determine if performance issues are due to RF impairments, without leaving the headend or hubsite. Figure 2 depicts a cable modem transmitting in 16-QAM, with MAC address 00:E0:6F:29:43:FE, which exhibits a 27.7 dB MER. Since 16-QAM transmissions require 18 dB plus MER, the technician can be certain that this modem is operating properly in the RF plant. However, if the MER of this particular modem was less then 18 dB, then the technician would know that the modem is experiencing impairments from the RF plant. With this information in a matter of moments a headend technician can determine if a customer's modem or MTA, for voice communications, is experiencing problems due to RF impairments from the physical plant. If plant related impairments are present, then a truck roll is likely necessary, however, if MER is good, the problem is unlikely due to the RF plant and the problem lies within the DOCSIS or IP network, which involves resources other than field technicians – a pointless truck roll stopped!

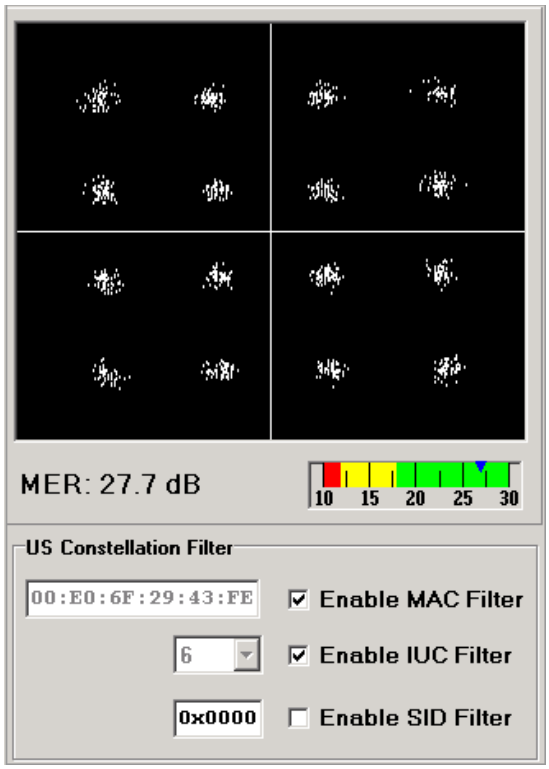

Figure 2. Upstream MER of a single cable modem

DOCSIS PROTOCOL IMPAIRMENTS

When DOCSIS-based devices violate the DOCSIS protocol, network failures are sure to follow. Using conventional RF test equipment to identifying DOCSIS protocol violations is not possible. Some diagnostic information is provided by the CMTS, but this usually only identifies that a problem exists and does not show the root cause of the problem.

In order to identify and isolate DOCSIS protocol violations, one must analyze the protocol in its native format – as RF modulated carriers in the RF plant. Additionally, DOCSIS commands have a format unlike any other in the communications industry, as defined by the DOCSIS specification. Cable operators must again turn to DOCSIS protocol analyzers in order to troubleshoot DOCSIS protocol related problems. The very same way the DOCSIS vendor community develops and troubleshoots DOCSIS-based CMTSs and CMs.

A DOCSIS protocol analyzer provides a user-friendly GUI interface to capture DOCSIS protocol and a viewer which presents the DOCSIS protocol in a format that is readable by the human eye (see figure 3). This output is a powerful tool for both identifying the presence of DOCSIS violations and for settling disputes with vendors providing equipment that violates the DOCSIS specification.

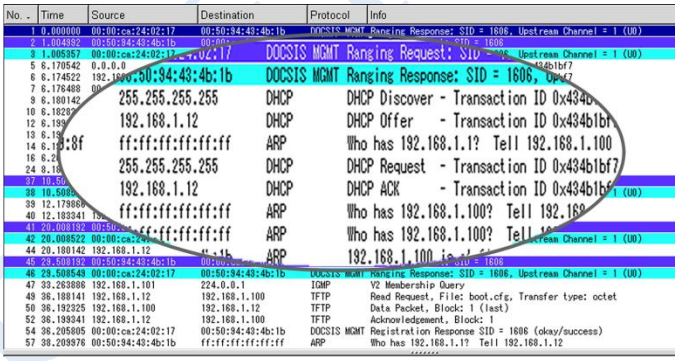

Figure 3. DOCSIS & IP Protocols from the RF Plant

IP LAYER IMPAIRMENTS

IP layer impairments impact both the subscriber and the DOCSIS network. It is obvious that for a cable modem and MTA to register with a CMTS, both the RF plant and the DOCSIS MAC must be functioning properly. But the IP layer is also critical for cable modem and MTA registration. First, the cable modem must receive a unique network address from a Dynamic Host Configuration Protocol (DHCP) server. Additionally, the cable modem must download a configuration file from a Trivial File Transfer Protocol (TFTP) server. Both the DHCP and TFTP servers transmit data over the IP network.

After cable modem registration, the IP layer is used by subscribers to transfer and receive IP data such as email, web pages, and gaming sessions, and MTAs for VoIP calls. IP layer impairments such as server failures, network congestions,

data delay and jitter, will provide a less than satisfactory user experience or may prevent the MTA from supporting the strongly desired VoIP services.

The IP layer also suffers from any RF or DOCSIS related impairments. For this reason, the IP layer resides at the top of the DOCSIS working model pyramid. Failures at any sub-layer directly translate to apparent failures at the IP layer. Failures at the IP layer translate to network reliability problems and subscriber complaints.

ACHIEVING RELIABILITY

DOCSIS protocol analyzers, when not being used for tactical purposes, can monitor downstream and upstream data communications of all DOCSIS devices. This information is archived to a database, which provides trend analysis information on cable modem/MTA MER, power, frequency, timing, and equalization adjustments. User definable thresholds can be set which automatically notify appropriate personnel when device operation becomes critical due to any number of impairments in the DOCSIS pyramid.

Consider a 1000 cable modem system. If just 3% of the modems in that system are offline on average due to difficult to resolve problems, this results in $18,000 in lost revenue per year at $49/mo./customer. Not considering the troubleshooting costs associated with the multiple truck rolls generally incurred with problem modems and repeat customer complaints, nor does it consider the cost of possibly losing the customer to a competing service such as DSL! DOCSIS protocol analyzers are the cutting edge at resolving hard to find problems in DOCSIS networks.

As with any new technology, an industry must learn new techniques and adopt new tools in order to make the technology successful. Improving DOCSIS network reliability requires new skills and new test equipment, in addition to the skills and test equipment we possess as an industry today. The tools and training for implementing and stabilizing DOCSIS networks are available. Cable Operators investing in these tools is critical in order to fully realize profitability from DOCSIS networks – Video, Voice and Data.

ACHIEVING THE TRIPLE PLAY

DOCSIS protocol analyzers serve as a critical element to achieving network reliability. Network reliability is the single greatest instrument to obtaining and retaining paying customers. It is the single greatest instrument to increasing revenue by decreasing cost associated with DOCSIS related issues. It is the metric that will determine the successful deployment of advanced IP services beyond simple email and web browsing. In order to compete with the Telephony industry it is no longer an option or a luxury - network reliability - is a necessity for the cable industry. A reliable network translates into achieving the Triple Play!

Learn more about DOCSIS Protocol Analyzers and troubleshooting DOCSIS @ www.volpefirm.com