IMPROVING DOCSIS RELIABILITY

DOCSIS™ RELIABILITY = INCREASED REVENUE

Data-over-cable System Interface Specification (DOCSIS) is the vehicle for cable operators to obtain immediate revenue generating opportunities such as Broadband Data, Voice over IP, IP Video-on-Demand, and countless emerging IP-based technologies. These growth channels rely on cable operators obtaining and retaining subscribers. Subscriber satisfaction with new services is a direct function of DOCSIS network reliability. 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.

DOCSIS WORKING MODEL

Developed by CableLabs, DOCSIS is the specification which provides a standard for bridging Ethernet data over a Hybrid-Fiber Coaxial (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) to communicate with the Cable Modem Termination Systems (CMTSs). Finally, the top of the pyramid represents the layer at which Ethernet data is transported. This layer is used both by subscribers for data access and by cable modems during registration (explained later).

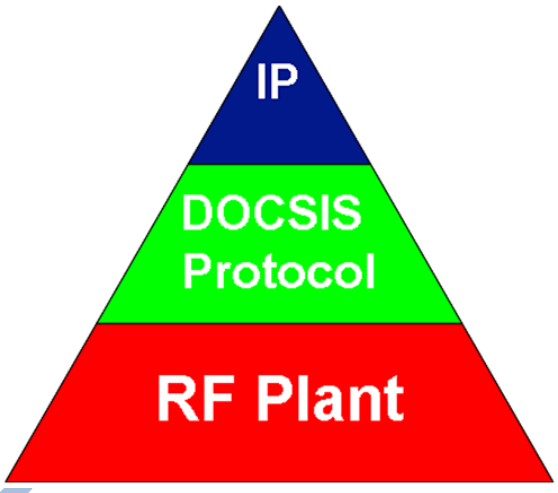

Figure 1. DOCSIS Working Model

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 often results in significant time loss and money expenditures attempting to resolve a problem which does not exist.

In order to solve the problem, I 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

Without question, 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

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inherently rich with mechanisms that will prevent or impair DOCSIS communications. Some very common and well know RF impairments are:

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

Individually, these impairments may impact DOCSIS reliability and can be difficult to identify using conventional test equipment. Collectively, these impairments create an environment that is impossible to certainly identify the source of network failures. Why is this so?

Analyzing individual cable modem performance requires a new breed of test equipment called DOCSIS Protocol Analyzers. These analyzers demodulate individual cable modem transmissions and provide not only a quantitative measurement of the signal's quality, but also provide information designating the source of the transmission. This is very important in DOCSIS networks because there exists hundreds, if not thousands of individual cable modem transmitters. A DOCSIS protocol analyzer can filter on a specific cable modem and provide signal quality measurements as shown in figure 2.

Armed with this capability, a cable technician can look at the signal performance of a single cable modem experiencing performance issues and determine whether or not the performance issues are due to RF impairments, without ever leaving the headend or hubsite. Figure 2 depicts a cable modem transmitting in 16-QAM, with MAC address 00:E0:6F:29:27:AC, which exhibits a 24.0 dB MER. Since 16-QAM transmissions only require 18 dB MER, the technician can be certain that this modem is operating properly in the RF plant. If, on the other hand, the MER of this particular modem was say 16 dB, then the technician would know that the modem is experiencing impairments from the RF plant.

The technician now knows whether the source of the network impairment is a problem in the RF plant or communications related problem, not involving the RF plant.

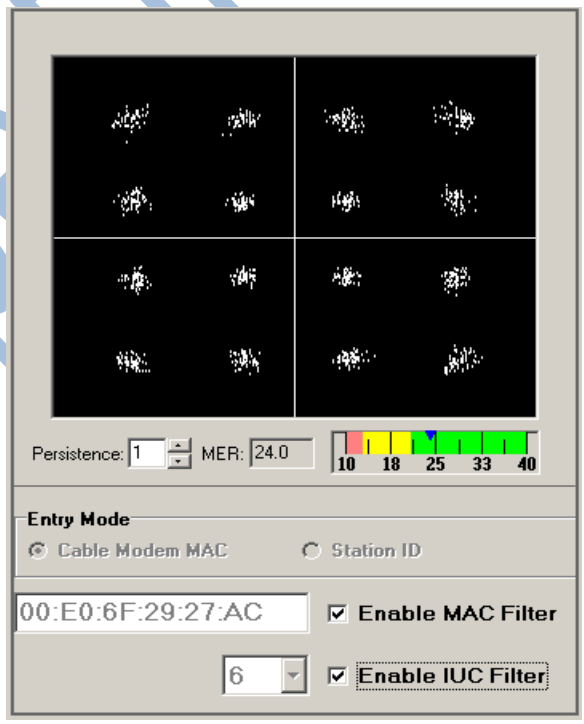

Figure 2. Upstream MER of a single cable modem

DOCSIS PROTOCOL IMPAIRMENTS

When DOCSIS-based devices violate the DOCSIS protocol, network failures are sure to follow. Using conventional RF test equipment in identifying the source of DOCSIS protocol violations is difficult, if not impossible. Some diagnostic

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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. 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.

IP LAYER IMPAIRMENTS

IP layer impairments impact both the subscriber and the DOCSIS network. It is obvious that for a cable modem 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 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. Additionally, the IP layer is where Voice over Internet Protocol (VoIP) calls reside. IP layer impairments such as server failures, network congestions, data delay and jitter, will provide a less than satisfactory user experience.

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 IS ACHIEVING THE DATA TRIPLE PLAY

Improving DOCSIS network reliability is not a single action or investment. Rather it is a conscious decision to implement a cradle-to-grave strategy to work the DOCSIS pyramid from the bottom to the top. This begins with investing in quality transmission equipment and using proven practices for installing, balancing and maintaining the HFC plant. Education and training play a strategic role in DOCSIS setup and maintenance, ensuring that the correct equipment is chosen and properly configured. 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. No longer is it an option or a luxury - network reliability - is a necessity for the cable industry to successfully capitalize on the Video, Voice, and Data Triple Play! ***(Expand on this paragraph using the facts you have on expenses from your slide show)***

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 data base, which provides trend analysis information on cable modem MER, power, and frequency, timing, and equalization adjustments. User definable thresholds can be set which automatically notify appropriate

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personnel when device operation becomes critical due to any number of impairments in the DOCSIS pyramid.

As with any new technology, for example fiber optics and digital video, we have learned new techniques and adopted new technologies in order to make the technology successful. DOCSIS is simply a new technology. The tools and training for implementing and stabilizing DOCSIS networks are available. It is now a matter of execution for cable operators to directly increase profitability by investing in the proper test equipment, training technicians how to use the equipment, and actually putting the equipment to use, is the final step.

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