Correlation Groups and vTDR Using DOCSIS Proactive Network Maintenance (PNM)

**A Technical Paper by
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Correlation and vTDR

Understanding correlation groups and vTDR (virtual time domain reflectometer) are key to unleashing PNM power

First the basics. Let us explain what causes an impairment in the outside plant that would lead to modems becoming part of a correlation group.

A cable modem will transmit an RF signal in the upstream. As the signal propagates through the coaxial cable if it encounters an impedance mismatch (i.e. micro-reflection), such as corrosion on a center seizure screw where the coax cable enters an RF amplifier or tap, the impairment will cause some of the RF energy from the modem to be reflected back to the modem. This is bad because upstream signals are only supposed to travel on the upstream, but it is now traveling on the downstream.

As the reflected signal propagates on the downstream it will eventually hit another active or passive device that will not pass upstream signals on the downstream. This will then reflect the original reflected signal back towards the CMTS in the direction it was originally meant to go. See Figure 1 for an illustration of how this works in theory.

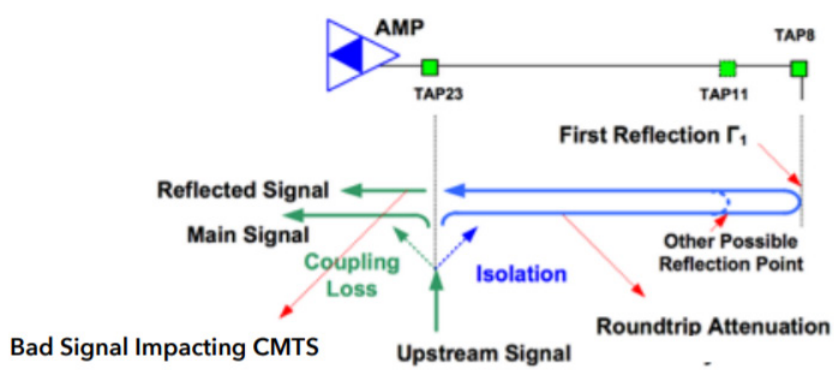


Figure 1: Reflected Cable Modem Signal (Source: CableLabs)

Analyzing figure 1 we see that physical Tap 23 is the source of the impairment. Some of the "main signal" is able to pass through physical Tap 23, however some signal is reflected by Tap 23 and reverses direction on the coax, now heading in the downstream direction. When it hits physical Tap 8 the reflected signal is prevented from going any further downstream because Tap 8 is assumed to have electronics inside not allowing upstream signals to travel on the downstream (often this may be an active device such as an RF amplifier).

The blue line shows the round trip distance, which is twice the span of the coaxial cable. The corresponding equalizer response for the Figure 1 is shown in figure 2 below:

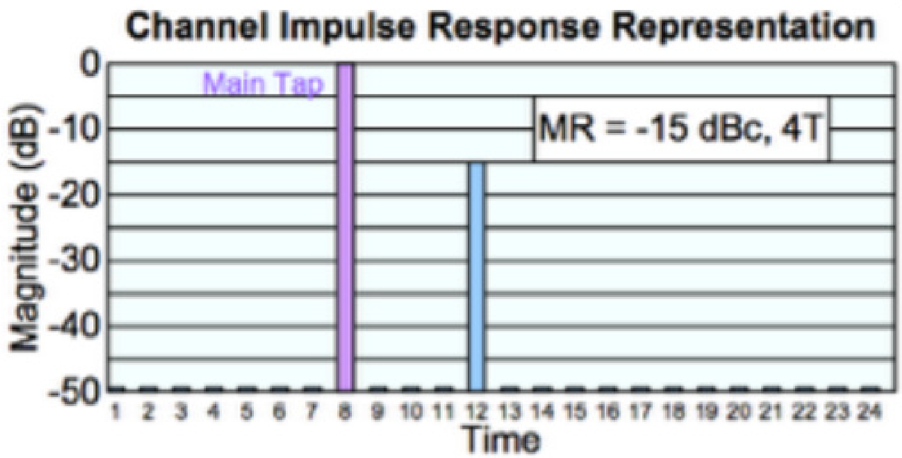


Figure 2: Pre-EQ Taps for Modem with Impairment in Figure 1

Figure 2 is an idealized tap response that shows one reflection at pre-eq tap 12. This must not be confused with physical Tap 23 and physical Tap 8, which are mainline passive devices in figure 1. The pre-equalizer taps are representations of digital signal processing elements.

Since pre-eq tap 12 is elevated we can estimate the distance to the impairment as four (4) taps after the main pre-eq tap (tap 8) as shown on the chart in figure 2. If the upstream DOCSIS channel is 3.2 MHz then each pre-eq tap represents approximately 170 feet, while if the upstream channel is 6.4 MHz each pre-eq tap represents approximately 85 feet.

Note: it is important to understand the difference between a 'physical tap' as in Tap 23 or Tap 8 shown in figure 1, which are used to drop coaxial cables to subscribers' homes, and digital signal processing taps also called equalizer taps as shown in figure 2.

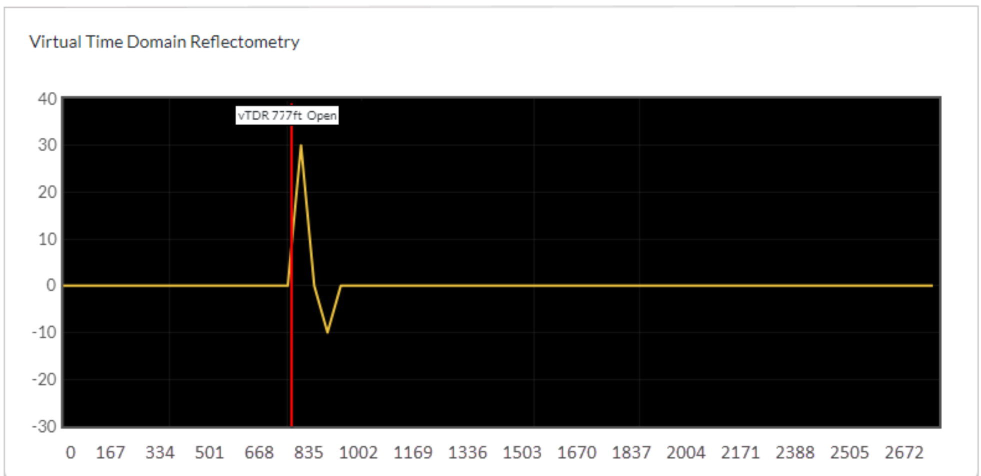
These two types of 'taps' are often confused in discussions about PNM. While both are 'taps', they are two very different terms and care must be taken to ensure the reader and user understand the difference.

The digital pre-eq tap 12 is elevated. Distance estimates can be made for each tap as 85' for 6.4 MHz upstream and 170' for 3.2 MHz upstreams.

Using the vTDR

The vTDR automates the calculation of the distance in the pre-eq tap values. This is the same number that was previously reported as FarTDR in the PNM table. The vTDR distance values use an interpolation of the peak pre-eq tap value along with the two adjacent pre-eq tap values in order to obtain a more precise distance calculation than what would be achieved by using a single pre-eq tap. By doing this we are able to achieve distance accuracies well beyond the 170' or 85' of the single pre-eq taps.

Figure 3 shows an illustration of the vTDR



Notice that the vTDR not only reports the impairment distance, but also indicates if the impairment is an 'open' or a 'short'. First consider the example in figure 1. The vTDR is telling us that distance from physical Tap 8 to physical Tap 23 (the impairment) is 777 ft. Next it is telling us that the source of the impairment is an 'Open'. What does an Open condition mean? See the tip chart on the left.

Using vTDR in Correlation

vTDR is only useful when you have a good correlation group. Further, not all correlation groups are created equal. The first step to getting a getting a good correlation group is to run the correlation algorithm prior to analyzing any correlation group. This is done by selecting Data > Correlate from the menu. The correlation process should only take a few seconds.

Once correlation is complete select a correlation group from the 'Correlation Group:' drop down box. Blue icons are modems that are part of the correlation group and have a common impairment. Grey icons are modems that are not part of the correlation, but are on the same upstream and same frequency as the blue modems. This means that the blue and grey modems are on the common HFC upstream port and frequency. It is important to understand this concept.

When you see a group of blue modems clustered together separated by a group of grey modems it can be deduced that the coaxial cable connecting the blue and grey modems is the likely source of the impairment. See figure 5 for this example.

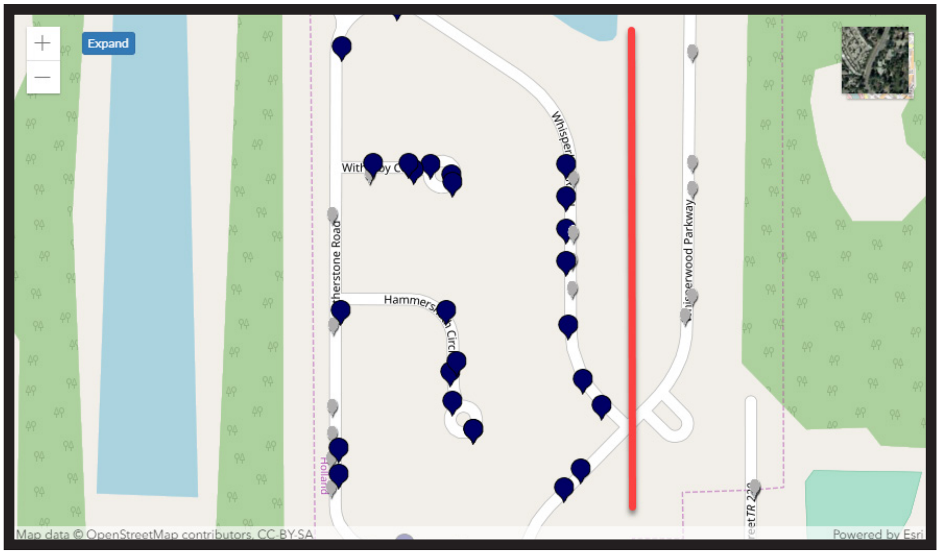


Figure 5: Strong Correlation Group - Red Line is demarcation between impaired modems (blue) and non impaired modems (grey). Now plant maps can be used to identify the coax and actives / passives that may be causing the impairments. Finally vTDR will tell you distance on that coax.

Figure 5 shows a strong correlation group because a clear demarcation line can be drawn between the blue modems (impaired) and the grey modems (not impaired). Note there are some blue modems mixed in with the grey modems. This is typical and is due either to geo-location errors or to correlation of similar, but not related impairments. It is up to the user to use discretion in order to visually eliminate obvious outliers.

A caution to users is to avoid obvious weak correlation groups. This occurs when multiple impairments with similar characteristics exist on the same upstream. No dominant impairment exists that impacts a significant number of modems, therefore a large cluster does not manifest. In these cases the user can ignore these correlation groups. Figure 6 is a good example of a weak correlation group which should be ignored.

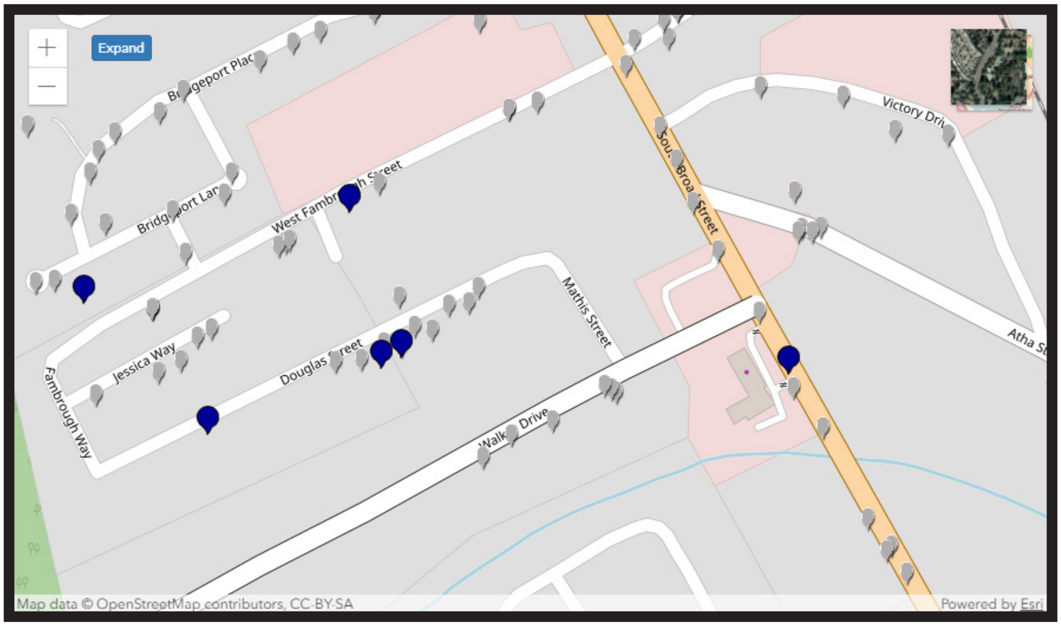


Figure 6: Weak Correlation Group

In the above weak correlation group we do not see any strong cluster of modems. It is recommended to ignore this correlation group.

Weak Correlation Groups are those that do not have blue modems clustered together in any specific location. This occurs when there is not a strong single impairment in the outside plant. It is recommended that the user does not focus on weakly correlated groups.

About Brady Volpe

Brady Volpe, President and Founder of The Volpe Firm, Inc. and Nimble-This, LLC, is involved in providing technology consulting services and products to cable and telecom operators & vendors World-Wide. Mr. Volpe has over 20 years of broadband cable and telecommunications industry experience specializing in DOCSIS, PNM (Proactive Network Maintenance), MatLab Simulation and Design, VoIP, Video, IPTV, RF, Digital Design, IP Security, EPON, FTTx, SIP, Capacity Planning, Fiber Optic Transport and all things broadband.

A highly respected speaker and industry thought leader, Mr. Volpe is a frequent presenter at domestic and International industry trade shows, conferences and regional seminars. He has published numerous articles in worldwide trade journals and authored several white papers on DOCSIS protocol and VoIP test and analysis. Mr. Volpe lends his expertise to industry associations and protocol bodies and is often sought out as an authority on DOCSIS, PacketCable, and VoIP. In addition, Mr. Volpe is a long time IEEE, SCTE and SCTE standards member. He holds patent number 7,885,195, "Test System with User Selectable Channel." His blog located at volpefirm.com, is the industry's most comprehensive DOCSIS tutorial and is used by a major MSO for training and educating their workforce.

Mr. Volpe earned his master's degree in electrical engineering, graduating with Honors (4.0) from John Hopkins University Applied Physics Laboratory in 2004. He received his bachelor's degree in electrical engineering from the Pennsylvania State University. Throughout his studies, Mr. Volpe focused on advanced telecommunications.