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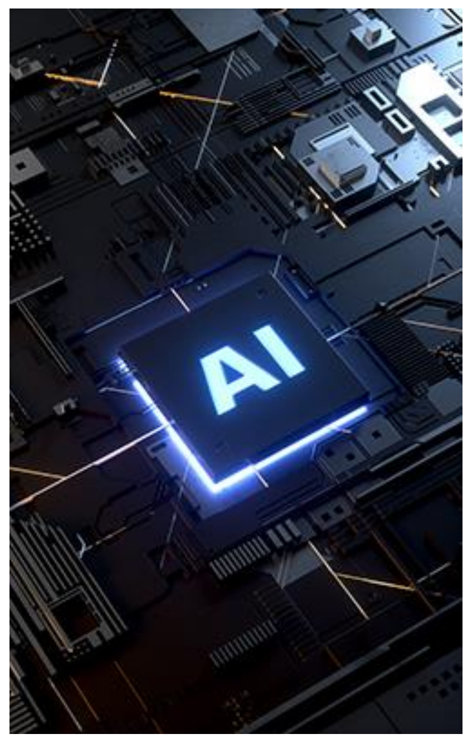
Using AI to Automate HFC Upstream Noise Localization

By: Dr. Foad Towfiq



Since the inception of Data Over Cable, DOCSIS network operators have faced the difficult task of locating upstream noise in the network. This difficulty is mainly due to the branch-tree architecture of the coaxial part of the HFC network, which allows all noise originated from any points to accumulate in the upstream direction and affect all the subscribers' cable modems on that upstream channel.

Beyond the fact that a *single* noise problem affects *many* customers, it is extremely difficult to pinpoint where the noise problem is. The network management approach has evolved and improved, but cable operators are still facing the same challenge. In most cases, technicians trying to find the source of noise issues must start from one end of a node and work their way through the network. To make matters worse, technicians' actions like this can impact large groups of customers, many of whom were not affected in the first place—for example, when the diagnostic step involves disconnecting network legs to see if the noise "goes away."

The costs mount quickly! There is a direct technician cost of working for hours, days and even weeks to find such issues, plus there is the cost of customer dissatisfaction, and ultimately the opportunity cost of spending so much time on diagnosing noise issues that could be better spent doing proactive maintenance on the network. Operators need solutions to help pinpoint the causes of noise, thereby lessening the impact on customer satisfaction, and freeing up technicians to pursue other critical network issues.

A short history of AI technology

As quoted from Buchanan, 2006: “The history of AI is a history of fantasies, possibilities, demonstrations, and promise. Ever since Homer wrote of mechanical “tripods” waiting on the gods at dinner, imagined mechanical assistants have been a part of our culture. However, only in the last half century have we, the AI community, been able to build experimental machines that test hypotheses about the mechanisms of thought and intelligent behavior and thereby demonstrate mechanisms that formerly existed only as theoretical possibilities.” While the foundation of AI was set in the 1950s by such pioneers as Alan Turing, the hardware needed to deliver true AI has only become available in the last 20 years. With the theoretical foundation of AI in place, and hardware now available that is powerful enough to deliver, AI technology is changing the world every day.

Another AI pioneer, Marvin Minsky at MIT, sought to use more advanced software logic with well-crafted subject-matter-expertise types of logic running on Expert Systems. This track of AI R&D achieved some results but was ultimately deemed too brittle for practical, economic use. Another track of AI R&D developed to apply Neural Network methods to seek a similar result, essentially to apply large decision-tree paths as networks of local decision-making in response to data inputs and allow the AI system to make more informed and intelligent recommendations based on given inputs.

In contrast to these traditional models of AI development, the recent success stories in AI revolve around fully using the massive improvement in compute-power in Big Data processing. New ML models now use the available compute-power to process massive amounts of data with repetitive, nuanced software logic that leads to unexpectedly brilliant conclusions about “what all that data means.”

This important synergy connects the DOCSIS network operators’ noise dilemma with the Big Data processing and new success with AI ML models, leading to surprising results with noise localization. This new form of AI has allowed Promptlink to deliver innovative new network management solutions, adding new capabilities to improve cable operators’ business—and their customers’ cable experience.

Looking toward solutions

The amount of data produced in a DOCSIS network is extremely large, and using human analysis, it is virtually impossible to correlate the data points with enough precision to be able to predict where and when noise is occurring. Promptlink’s decades of experience in the field pointed the way to R&D efforts using AI modeling and machine learning (ML) to overcome this problem. We now apply data science techniques and ML to evaluate the massive amount of network management data and pinpoint possible noise locations for investigation. This Promptlink technique also provides instructions for technicians to diagnose specific impairments causing the noise and repair them.

Noise in an upstream channel, no matter where it originates, affects all the modems communicating on the channel. A Big Data approach that looks at many different interfaces on the channel supplies a way to detect the signature of the noise, identify the type of impairment that can cause the type of noise present and pinpoint the type of network elements that such impairment can be present in.

Multimodal machine learning approach used in noise localization

One of the most promising areas in AI research is multimodal machine learning (MMML), which aims to build models that can interpret multiple streams of data in the process of deducing a hypothesis of what it is looking at. For example, when identifying the make and model of an unknown car using machine learning techniques, it is possible to train the ML engine using a set of labeled pictures of the different cars or a set of labeled sound data from different cars traveling at different speeds. A multimodal ML engine in this case would have a model that can interpret both pictures and sound data sets and predict much more accurately the make and the model of an unknown car.

In the case of noise localization, a similar approach would provide a more accurate prediction of a source point of noise. The Promptlink approach with multimodal machine learning in noise localization initially considers all network elements (amplifiers, splitters, taps, and more) plus the customer premises, including passives and the CPE inside the home, and the network segment between the two network elements. Any of these can be considered and labeled as Points of Interests (POI), where noise is most likely being generated with certain equal probability. Using different data sets, the probability for a POI being ***the*** point (or ***one of the*** points) of noise is re-estimated. Therefore, the noise localization will run iteratively and end up finding the Points of Interest with the highest probability of being the source of noise.

Furthermore, other data science techniques are applied to extract additional information such as types of noise, types of impairments causing noise and types of network elements where the impairment can happen.

Parameters obtained or predicted using data science techniques and used in multimodal machine learning include:

Types of noise

- Noise generated ***inside*** the network: This category is generally related to different nonlinear distortions. It can be caused by amplifier misalignment or by corrosion in passive network elements. Examples of this type of distortion are common path distortion and passive intermodulation distortion.

- Noise ***entering*** the network ***from outside*** (Ingress): This category also has several different characteristics. Impulse noise caused by machines is a good example. Other examples are white noise or any other noise that is present in the environment along with impairment, such as physical damage to a cable or a loose connector, which allows the outside noise to enter the network.

Noise variation

Noise is not constant in time. It can vary gradually or be intermittent. Noise can also be periodic, indicating possible effects of the environment. There are certain types of noise that can appear only at night or only during the day. There are also other noise cases that are affected by temperature, wind, rain, and so on.

Types of impairments

Some network impairments are potentially the points of noise origination.

Downstream noise

In some cases, the impairment causing upstream noise can also be the cause of downstream noise.

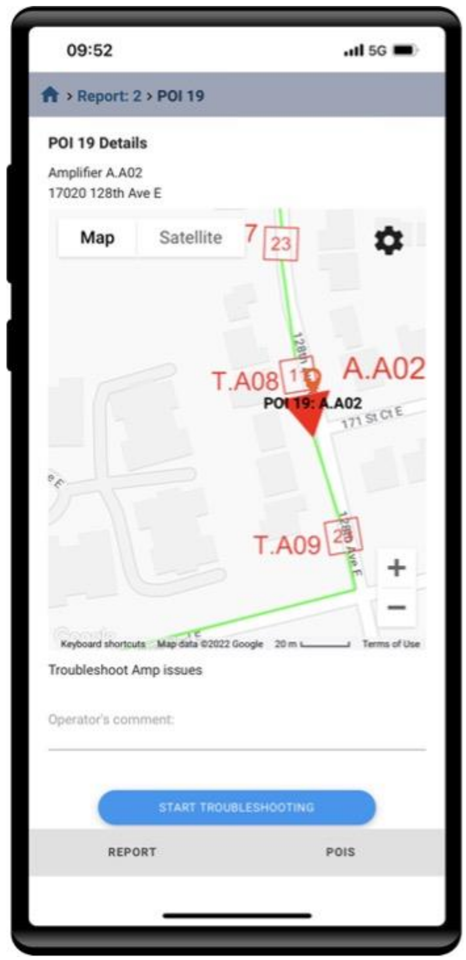


Figure 1: Sample NAIL report showing type and location of POI

Once all these techniques generate POIs, the POIs must be packaged in such a way as to be useful to a dispatcher and ultimately a technician. Operators want a prepackaged result that can be given to technicians without further analysis. Promptlink's approach was to create a Noise Impairment and Localization (NAIL) Report. This report gives explicit instructions on how to locate and correct the impairment or impairments causing the noise and takes feedback from the work done to further refine the data analysis, making the tool more accurate over time.

Conclusion

The persistent problem of isolating cable network noise is now being resolved with the use of advanced AI modeling from the research and development done by Promptlink. By combining an "all of the above" data collection approach from multimodal aspects of the HFC environment, and use of ML logic to process the Big Data sea of valuable data points, Promptlink's NoiseHawkAI product offers operators a way to quickly pinpoint locations for technicians to work and rapidly resolve noise problems.