INVENTION DISCLOSURE

1. **Invention Title.**

Network failure detection and prediction using DOCSIS 3.1 pilot measurements

2. **Invention Summary.**

This invention targets network health monitoring and network failure detection and prediction using opportunistic scheduling and measurement of pilot power in various bands to detect second order and third order harmonics created by equipment induced distortions. This invention also enables Identifying impairment location and predicting equipment failure.

3. **Invention Description**.

This invention targets identifying equipment failure and specifically amplifier failure and non-linearity in the network by remotely monitoring (via the CMs) the behavior of opportunistically placed DOCSIS 3.1 pilots placed in a downstream frame.

To achieve this, the CMTS selects a frequency bin (f1) and two symbol slots (t1,t2), preferably back to back, that shall be monitored by the CMs. During allocation "f1,t1", the CMTS sends a pilot pattern, while in "f1,t2", that allocation is nulled (nothing is sent).

To detect network impairments due to amplifier problems, the CMs measure the energy levels at allocations: "3xf1,t1" , "2xf1,t1" and "3xf1,t2","2xf1,t2".

If the signal energy in the t2 symbol slots are measured to be higher than the signal energy in the t1 symbol slots, then this is an indication that an amplifier in the network is causing signal distortion and generating 2nd order and 3rd order distortions (a.k.a. composite triple beat and composite second order distortions).

Procedure:

Measure signal energies during 3xf1,t1 and 3xf1,t2 (E1 and E2 respectively)
Measure signal energies during 2xf1,t1 and 2xf1,t2 (E3 and E4 respectively)
Calculate E1,2=E1-E2 and E3,4=E3-E4.
If either of E1,2 or E3,4 > Threshold then:

- Signal distortion is present
- Second order and/or third order harmonics are being created
- Conclusion is network element is failing or causing distortion

By comparing the results from various CMs, and identifying which ones are suffering from distortion in the network and which are not; the location of the element in the network that is causing distortion can be identified. Additionally, by tracking E1,2 or E3,4 over time, equipment failure can be predicted. As a continuous increase in the difference in the energy levels would be an indication that a piece of equipment is approaching EOL.

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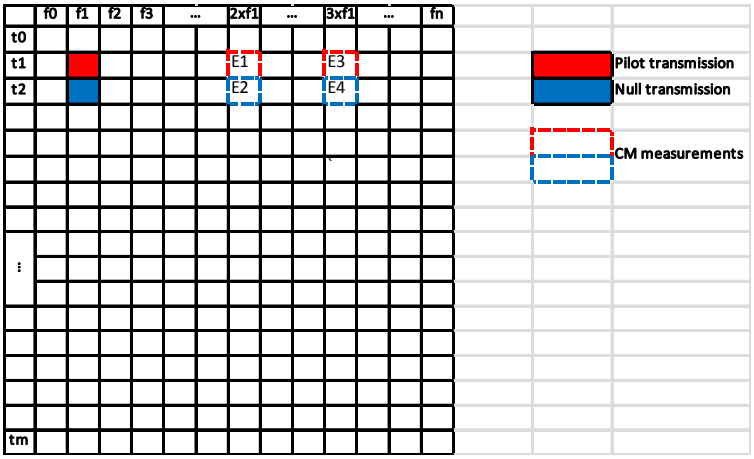

A potential addition to the invention would be the incorporation of two tone tests by having two pilots transmitted at the same time separated by a certain frequency gap. The measurement would be conducted in the intermodulation expected frequencies. This would allow intermodulation distortion testing.

A second potential addition would be to adapt this disclosure to the US. In this case the CMTS would have to generate gaps in spectrum for the 2nd and 3rd harmonic frequency locations by shifting the minislots when a suspect nonlinear problem is expected from a particular CM. In the US it has too be targeted to one cable modem at a time. In the downstream it covers all CMs.

Briefly outline the potential commercial value and customers of the invention.

This invention enables network monitoring without the need for additional equipment or interruption of service, thus a low cost solution which can be scaled easily. This solution can be automated within a CMTS to enable ongoing real time monitoring and reporting. Additionally, detecting network failures in a short time and having the ability to predict equipment failure minimizes the down time of the network, thus increasing customer satisfaction and QoS.

4. **How is this invention different from existing products, processes, systems?**

This solution requires very minimal processing power, data returned to the CMTS from the CM is minimal thus low overhead, and can be integrated within the CMTS and CMs with low complexity and overhead.