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ADAPTIVE CABLE BANDWIDTH OPTIMIZATION WITH DEEP CONVOLUTION NEURAL NETWORK

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ABSTRACT

Techniques are described herein to determine the optimal modulation of a channel in real time. Cable bandwidth usage is improved using a state-of-art deep convolutional neural network.

DETAILED DESCRIPTION

Cable networks are often subject to a Radio Frequency (RF) variably noisy environment. The modulation of a channel needs to be adjusted based on the noise condition. According to Data Over Cable Service Interface Specification (DOCSIS) 3.1, a channel has up to 8096 Subcarriers (SC) whose Modulation Error Ratio (MER) are monitored. Due to the high number of SCs, it can be challenging to dynamically choose a modulation profile that works best for the current noise condition in order to maximize bandwidth usage. The techniques described herein solve this problem by determining the best modulation profile in real time.

MER is used as input to determine whether modulation is optimal, or needs to be upgraded or downgraded with a noise condition. The method may be used for both upstream and downstream. The following description is for downstream. First, in a lab environment, a cable channel is configured with one fixed modulation, and cable modems are connected to and use the channel. Various noise conditions are generated and the modem's receive errors are checked. The MER of each subcarrier of the channel is polled. If there are no correctable errors for five minutes, the MER array is given a label '0' meaning "can be upgraded to a higher modulation." If there are correctable errors, but no non-correctable errors, or only very occasional non-correctable errors in five minutes, the MER array is given a label '1' meaning "stay with current modulation." If non-correctable errors continue, the MER array is given a label '2' meaning "needs downgrade to a lower modulation." RF meters may be used to assist in improving the accuracy of the labels.

After generating hundreds or thousands of MER arrays and labels, the MER data may be normalized to a fixed length, such as 2048, with extension or squeezing. This is because the MER array length can differ depending on the channel configuration, but a fixed input size is needed for a deep convolutional neural network. Linear interpolation is used for extending the length, and averaging is used to squeeze the length.

The normalized MER data and the labels are divided into training and verification data with a ratio of 70/30. A deep convolutional neural network with two convolutional layers, two pooling layers, and two fully connected layers are trained with the training data. Upon convergence, the verification is used to verify the model, which showed accuracy over 92% in one such experiment. After training and verification, the model can decide in real time whether a channel's modulation should "be upgraded," "stay with current modulation," or "be downgraded."

Lab tests showed that this approach can improve bandwidth usage by 9% in one test case when compared with current approaches. The techniques described herein build a model based on thousands of different noise conditions, CM receive errors, and expert opinions for improved performance.

Figure 1 below illustrates the machine learning approach and results described herein.

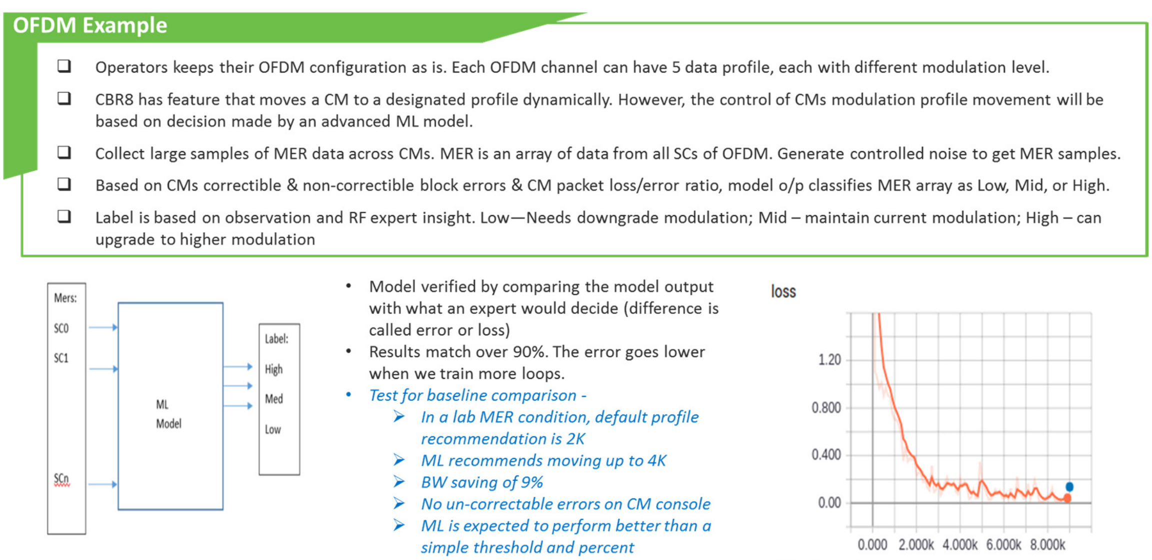

Figure 1

In summary, techniques are described herein to determine the optimal modulation of a channel in real time. Cable bandwidth usage is improved using a state-of-art deep convolutional neural network.