A Live System for Wavelet Compression of High Speed Computer Network Measurements

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1 Introduction

Monitoring high-speed networks for a long period of time produces a high volume of data, making the storage of this information practically inefficient. To this end, there is a need to derive an efficient method of data analysis and reduction in order to archive and store the enormous amount of monitored traffic.

Satisfying this need is useful not only for administrators but also for researchers who run their experiments on the monitored network. The researchers would like to know how their experiments affect the network's behavior in terms of utilization, delay, packet loss, data rate etc.

In this paper a method of compressing computer network measurements while preserving the quality in interesting signal characteristics is presented. Eight different mother wavelets are compared against each other in order to examine which one offers the best results in terms of quality in the reconstructed signal. The proposed wavelet compression algorithm is compared against the lossless compression tool bzip2 in terms of compression ratio (C.R.). Finally, practical results are presented by compressing sampled traffic recorded from a live network.

2. Methodology

Wavelet analysis is not a compression tool but a transformation to a domain that provides a different view of the data that is more eligible to compression than the original data itself. This happens because small wavelet coefficients can be discarded without a significant loss in the quality of the signal. On the other hand, large coefficients represent important characteristics of the signal and they should be kept.

Gupta and Kaur [1] proposed an adaptive thresholding technique that is calculated from the value of the wavelet coefficients. This scheme is not based on signal denoising but rather tries to statistically identify significant coefficients.

Afterwards, normalization and run length encoding are applied. For the simulation experiments thirty delay and thirty data rate signals of 1024 points were used. The delay signals were measured over the test bed of High Speed Networks (HSN) research group. The data rate signals are from a real commercial network.

3. Wavelet Comparison

Eight wavelets were chosen and compared against each other in order to find out which one offers better reconstruction results. The following wavelets were compared: Haar, Meyer, Biorthogonal 3.9 and Daubechies D4, D6, D8, D10, D12. The index of Daubechies wavelets indicates the number of coefficients. The number of vanishing moments each Daubechies wavelet has is half of the number of coefficients.

Wavelets with many vanishing moments are described with many coefficients in the scaling and wavelet functions, thus increasing the computation overhead of the wavelet transform, the complexity of the algorithm and the output file size. Table 1 shows the average PSNR value after reconstruction at level 6 for thirty delay and data rate signals.

Table 1. Average PSNR for delay and data rate signals after reconstruction at level 6

Wavelet	Haar	D4	D6	D8	D10	D12	Meyer	Bio3.9
PSNR (db) Delay	39.60	38.25	37.65	37.47	37.05	36.97	37.08	37.35
PSNR (db) Data Rate	55.16	54.06	53.99	50.69	52.59	53.02	54.91	51.72

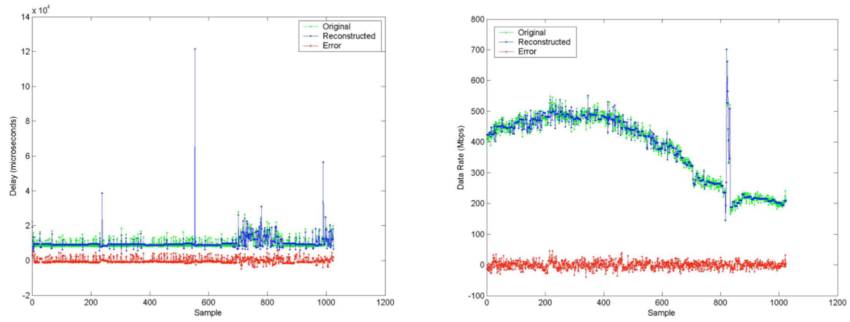
The Haar wavelet provides higher PSNR values for the reconstructed signals in both delay and data rate signals and has the following advantages: It is conceptually simple, fast, memory efficient and exactly reversible without producing edge effects.

4. Simulation Results

Fig. 1a shows a delay signal, before and after the compression. Because the two signals are very similar, the error between them is also provided for better judgment (lower line). The signal is decomposed at level 10 and the reconstruction quality is 37.85 dB while the C.R. is 13.7. PSNR values less than 35 dB loose some of the important signal characteristics while PSNR values less than 30 dB are not acceptable for such signals.

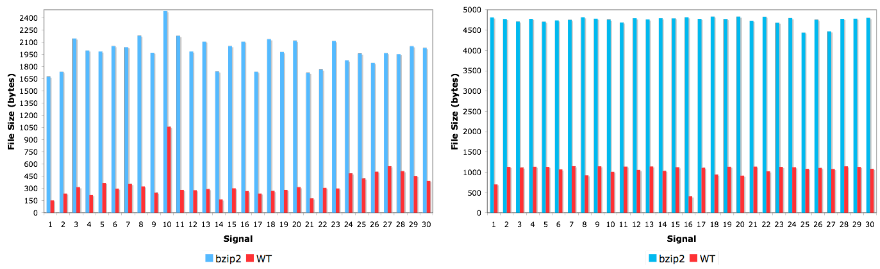
Fig. 1b shows a more interesting case of a data rate signal. This signal includes a spike, which is kept intact after the compression. A characteristic of the proposed algorithm is that it detects the spike as a more interesting feature than the rest of the signal. As a result, the algorithm's first priority becomes to preserve this characteristic and then comes the rest of the signal. The PSNR is 35 dB and the C.R.= 26.57.

Fig. 2 compares the C.R. results of the suggested wavelet technique against bzip2. It is interesting to examine the results from wavelet transform against a non-transform compression technique. In average, for delay signals (Fig. 2a) the suggested method (WT) achieves compression 6.5 times more than bzip2 with the best score being 11 times and the worst score 2.3 times. For data rate signals (Fig. 2b) the average compression is 4.7 times more than bzip2 with the best score being 12 times and the worst 4 times.



(a) (b)

Fig. 1. (a) Delay signal 30 decomposed at level 10, PSNR= 37.85 dB. (b) Data rate signal 16 analyzed at level 5 with PSNR = 35.4 dB



(a) (b)

Fig. 2. Compression performance of the wavelet algorithm against bzip2 for delay (a) and data rate (b) signals. Each examined signal is located on the x-axis. The y-axis shows the file size in bytes.

5. Practical Results

The full algorithm is already implemented in CoMo. CoMo is a passive monitoring platform developed for the purpose of monitoring network links at high speeds and replying to real-time queries regarding network statistics. CoMo has various modules that each calculates one or more network measurements [2]. The proposed algorithm can be imbedded in the modules and compress these measurements. When CoMo receives a query, the information is first decompressed and then shown to the end user.

The experiment lasted for 8 days and CoMo was monitoring traffic recorded at HSN research group's live network. The overall achieved compression is 34.5 times. Fig. 3 presents a segment of 34 minutes from the 8 days duration experiment. This signal is characterized by discrete bursts of data rate. Some have amplitude of 70 kB/s while others are half that size or less. The reconstruction keeps intact the peaks and smoothes out the relatively small variation of the signal. PSNR for that segment is 55.9 dB.

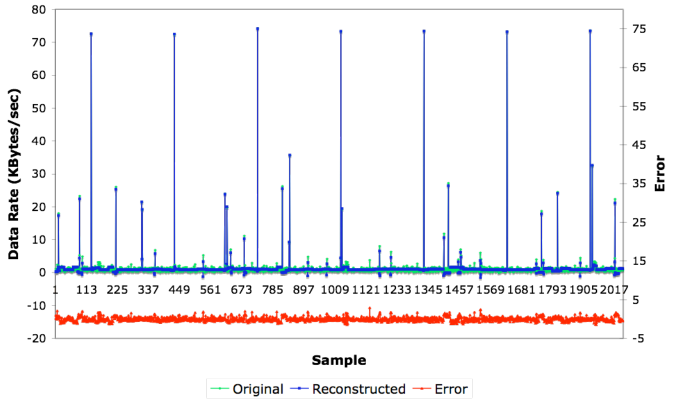


Fig. 3. Segment of 34 minutes of a data rate signal compressed live by CoMo. Error is given on the secondary y-axis on the right.

6. Conclusions – Future Work

This paper proposes the use of wavelet analysis techniques along with a wavelet coefficient thresholding method for compressing computer network measurements such as data rate and delay. Even though the compression is lossy, the important characteristics of the examined signal are preserved. In order to increase the compression, the detail characteristics are smoothed out by discarding the corresponding detail coefficients.

An evaluation of various wavelets with increasing vanishing moments was presented in order to determine which wavelet is more appropriate for performing the analysis. From simulation results, the Haar wavelet is found to be the best option as it offers the best results in terms of quality and compression ratio

However, some improvements should be done in how the algorithm deals with the threshold in cases that spikes occur in an already bursty signal like in signal 16 (Fig. 1b). This would lead to more control over the quality of the reconstructed signal and more consistent PSNR values.

References

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2. Gianluca Iannaccone, Christopher Diot, Derek McAulley, Andrew Moore, Ian Pratt, Luigi Rizzo, " The CoMo White Paper", INTEL research technical report