Unequal Error Protection for Wavelet-Based Wireless Mesh Transmission

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1 Introduction

The increased popularity of networked graphics applications that utilize 3D models, necessitates the storage and transmission of large meshes. To mitigate low wireless bandwidths, we propose a wavelet-based framework that permits progressive transmission and rendering of large 3D models. A server only needs to send connectivity information of a base mesh and corresponding wavelet coefficients to mobile devices, saving bandwidth and memory. However, wireless channels exhibit very high bit error rates. Retransmission (or ARQ) and Forward Error Correction (FEC) schemes are the two most common strategies for handling transmission errors. We propose a new transmission method that reduces packet loss caused by wireless errors. Our scheme uses a FEC technique based on the principle of Unequal Error Protection (UEP) to make mesh transmission more error resilient.

[1] previously applied the UEP method to Compressed Progressive Meshes (CPMs). Our work focusses on applying UEP techniques to wavelet-based wireless mesh transmission.

2 Unequal Error Protection (UEP)

UEP adds a variable amount of FEC protection codes to encoded (or mesh) bits, that depends on the amount of information they contain. First, encoded bits are classified based on their contributions to the final decoded mesh. Each class is then protected by a FEC code that provides a certain level of protection against channel losses. In our work, the encoded bitstream consists of a base mesh and a number of levels of wavelet coefficients that refine the base mesh. The base mesh and various coefficient levels are assigned an FEC code depending on their contribution to the decoded mesh quality. The most important parts of the mesh consume the largest portion of the error-protection bit budget. In our case, the levels of wavelet coefficients with large absolute values contain more information and hence receive more UEP error bits. Reed-Solomon (RS) FEC codes are used.

To determine the level of channel coding necessary for each level of coefficients, a certain distortion metric that expresses its relative importance, is needed. The distribution of FEC code rates to the different levels is based on this distortion quantity measure. The main terms in the distortion measure are: 1) The wavelet coefficients; 2) the total number of error-protection bits.

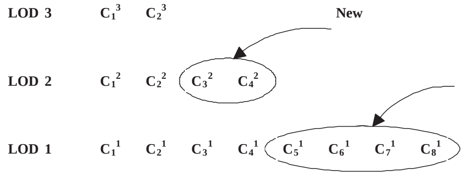

Figure 1: The Coefficients Tree for a mesh with three LODs. C_i^j is the wavelet coefficient at level j.

As figure 1 shows, when wavelets coefficients are encoded, at each level, the coefficients that have values that are greater than some appropriate threshold are kept and others are replaced by zero. We associate a coefficients distortion quantity, $D_{wLOD}^{(j)}$ with the j^{th} LOD, which is defined as the average distortion (per coefficient) introduced when all coefficients that are added by this LOD are lost. The $D_{wLOD}^{(j)}$ is given by:

$$D_{wLOD}^{(j)} = \frac{1}{N_j} \sum_{i=1}^{N_j} |c_i^j| \tag{1}$$

Where N_j is the number of coefficients added by $LOD^{(j)}$. This distortion measure estimates the error between the meshes with the j^{th} LOD and the $(j+1)^{th}$ LOD.

We use two wireless channel models. The first one is the two-state Markov model known as the Gilbert-Elliot (G-E) model that simulates the channel model with high error bit rate. G-E models are defined by the distribution of error-free intervals, called gaps. A gap is defined as the interval of length $v-1$ packets between two consecutive received error packets. This model is illustrated in figure 2. Equation 2 is its probability density function (pdf).

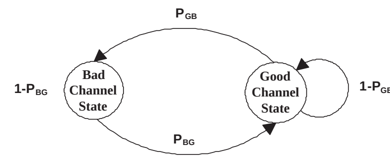

Figure 2: Gilbert-Elliot two state Markovian Channel Model. P_{GB} is the transition probability from the good state to the bad state. P_{BG} is the transition probability from the bad state to the good state

$$g(v) = \begin{cases} 1-P_{BG} & , \quad v=1 \\ P_{BG}(1-P_{GB})^{v-2}P_{BG} & , \quad v>1 \end{cases} \tag{2}$$

The second channel model uses the Rayleigh distribution which simulates the channel model with multipath fading. The probability density function (pdf) of the channel model is:

$$f_{ray}(r) = \frac{r}{\sigma^2}\exp(-\frac{r^2}{2\sigma^2}), r \geq 0 \tag{3}$$

3 Proposed Work and Summary

Our main contribution is extending the idea of UEP, to wavelet-based meshes in order to increase error resilience. In future work, by simulating our method on two different wireless channel models, we shall compare the performance of the proposed UEP method and EEP (Equal Error Protection) methods. We shall also compare the performance of the proposed Wavelet-based UEP method with Compressed Progressive Meshes in the presence of wireless errors using both subjective and objective methods.

References

[1] G. Al-Regib and Y. Altunbasak. An unequal error protection method for packet loss resilient 3d mesh transmission,. *IEEE INFOCOM*, '02.